SCIENCE EXPERIENCES WITH HOME EQUIPMENT

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by

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Foreword

These two hundred science experiences require only home equipment.

They have been tested many times and all are sure fire.

You will succeed in every case, if you follow the directions.

If you fail, read the directions more carefully and follow them step by step.

Do them yourself. It's more fun than looking on.

"Knowledge begins in wonder."

"All thought is based on experience."

"One experience is worth ten demonstrations."

Acknowledgment

The writer wishes to thank his colleagues, Professors Maurice A. Bigelow; Samuel Ralph Powers and Gerald S. Craig, for steady encouragement in the preparation of this series of books.

He wishes to thank also the following members of his classes for suggestions included in the series: Lincoln Baar; Clarence E. Baer; Frederick W. Bates; Mark P. Bedford; Joseph M. Cadbury; Eleanor Cleveland; Thomas F. Dolan; James K. Harris; Edgar M. Hoopes; John Dale Kelly; James F. Mason; Jesse V. Miller; Paul C. Mitchell; Ralph Preston; Charles E. Reck; Allan Scholtzhauer; C. Neale Stacy; Rudolph Steinberg; Karl Theman; Etta Ward Hastings; Robert S. Wheelock; Lester R. Willard and Edith Yelenfy.

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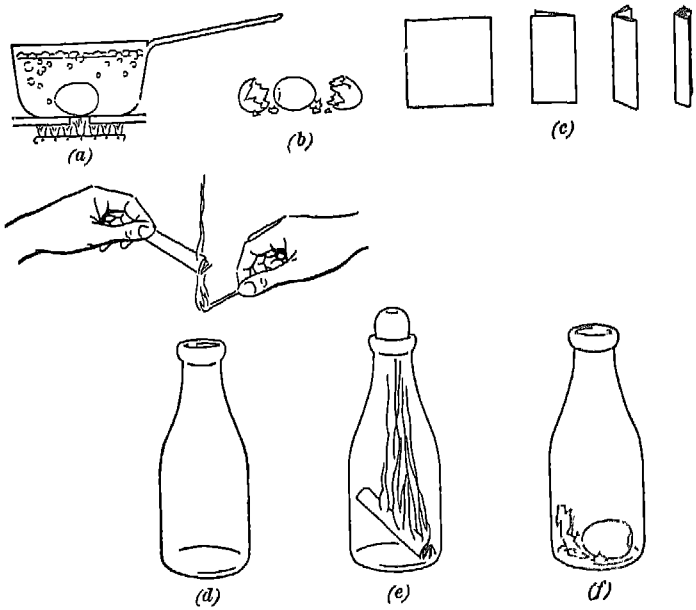


1. The Egg Pops In

a. Boil a fresh egg ten minutes.

b. Place it in cold water about ten seconds and remove the shell.

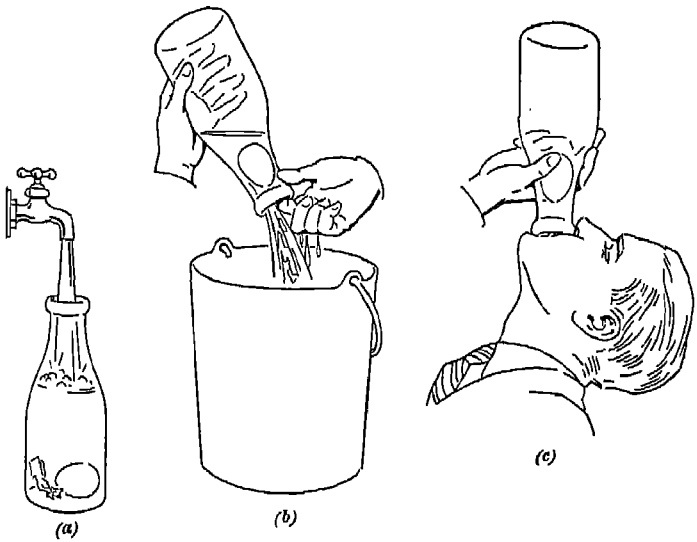
c. Fold a 4″ × 4″ piece of newspaper, or a *single* sheet of flat toilet paper, three times in the same direction.

d. Light the paper at the lower end.

e. Drop the lighted paper into a quart milk bottle and *quickly* place the shelled egg in the mouth of the bottle.

f. The egg will dance up and down and then pop into the bottle.

Why? See page 203.



2. The Egg Pops Out

a. Fill the bottle with water.

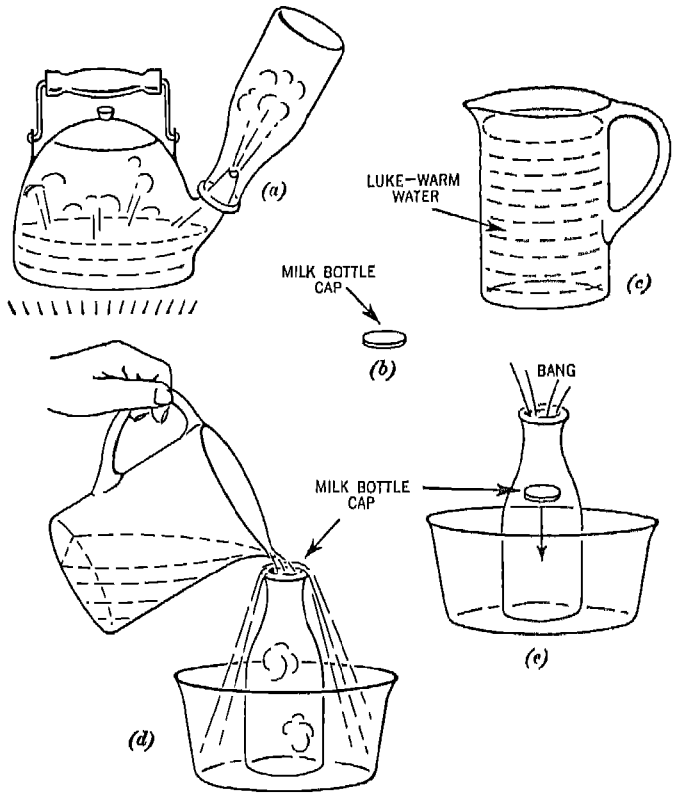
b. Invert it, hold the egg up with your finger and rinse out the burned paper.

c. Lean your head back *until your face is horizontal,* press the bottle mouth *air-tight* over your own mouth and puff *hard* into the bottle.

Lift the bottle and the egg will pop out.

Be ready to catch it.

Why? See page 204.



3. Bang!

a. Steam the inside of a quart milk bottle on a tea kettle spout for one full minute.

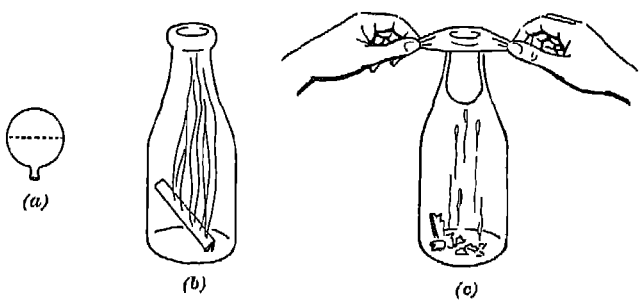
b. Find a sound cardboard milk bottle cap for it.

c. Fill a pitcher with luke-warm water.

d. Lift the bottle off the kettle spout with a towel; then, quickly stand it in a saucepan, insert the bottle cap air-tight, and pour luke-warm water on the cap *slowly and steadily* to keep it air-tight.

e. In two minutes or less you will see and hear the cap burst into the bottle with a "bang." If it does not, push the cap down gently with a finger and it will burst in with a "bang."

NOTE: You should have a tea kettle with a spout *narrow enough to go into the mouth of the milk bottle 1 inch or more* in order to be sure that the steam passes into the bottle to drive out the air. If not, make a cardboard tube 3 inches long. Shove one end into the tea-kettle spout and the other end into the mouth of the milk bottle.



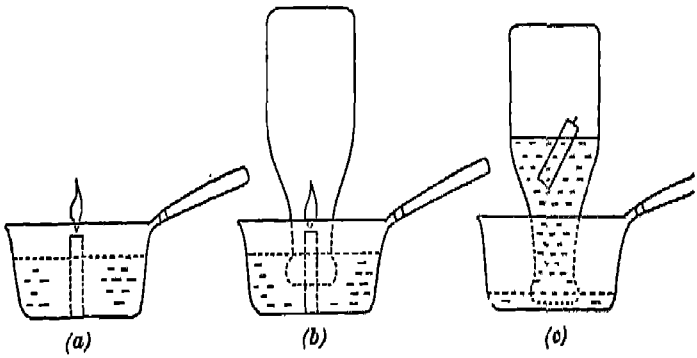
4. Bang!

a. Cut in two a medium size round balloon, two for five cents.

b. Fold a 4″×4″ piece of newspaper three times in the same direction, light it at the lower end, and drop it into a quart milk bottle; then very *quickly* continue.

c. Hold the bottom half of the balloon over the mouth of the bottle, and you will see the balloon rubber bulge upward at first and then stretch down into the bottle and break with a "bang."

Fill the bottle with water to the top to drive out the burned air and the burned paper.



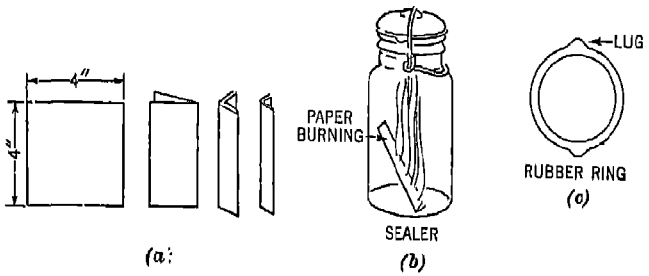
5. Milk Bottle and Candle

a. Fill a quart milk bottle half full of water and empty the water into a sauce pan. Stand a 2″ candle in the pan and light it.

b. Invert the empty quart milk bottle over the candle and hold its mouth about ¼ inch under the water surface until the hot air stops bubbling out.

c. Lower the bottle and you will see the water and candle rise up into the bottle.

Fill the bottle with water to drive out the burned air.



6. Quart Sealer

Put the rubber ring on the sealer and practice clamping down the cover until you can do it quickly.

a. Cut a piece of newspaper 4″×4″, or use a *single* sheet of flat toilet paper, and fold it three times in the same direction.

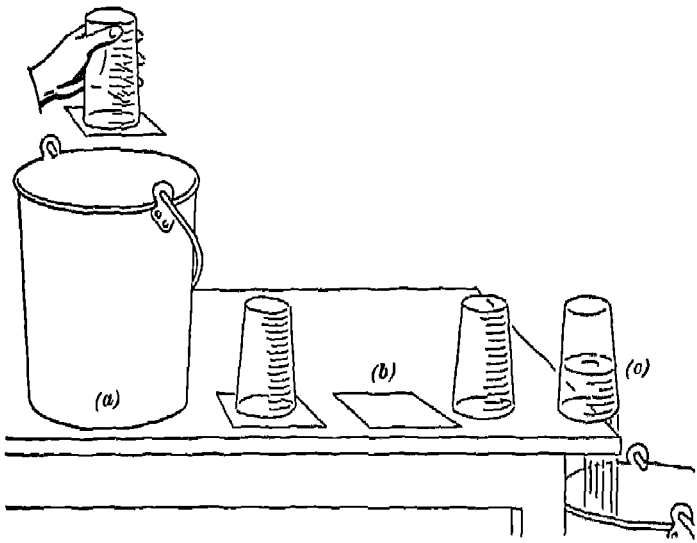
b. Light it at the lower end, drop it into the sealer, and clamp down the cover.

Wait for about one minute for the air in the sealer to cool, then unclamp the cover and try to lift it.

It is difficult.

c. Pull out the lug at the side of the rubber ring until air enters the sealer.

You can then lift the cover easily.

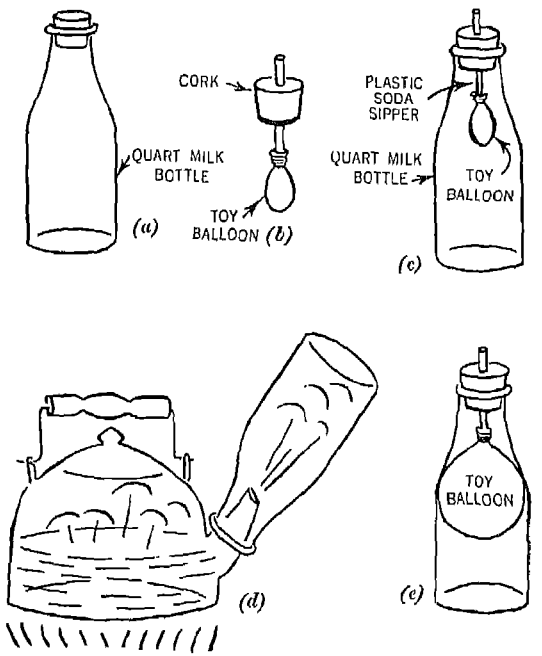


7. Tumbler and Paper

a. Fill a tumbler with water, cover it with a small piece of heavy wrapping paper, press the paper down with the palm of your hand to force out air and some water, invert both over a pail and remove your palm. The paper will stay on the tumbler.

b. Place the inverted tumbler and paper on the table and slide out the paper. The water will remain in the tumbler.

c. Slide the tumbler to the edge of the table and empty it into a pail.



8. The Atmosphere Expands the Balloon

a. Find an air-tight cork for a quart milk bottle.

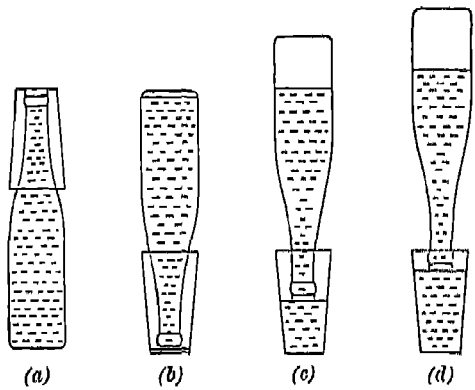
b. Bore a hole through the cork just large enough to hold a plastic soda sipper air-tight. Tie a small toy balloon to one half of a plastic sipper and shove the half-sipper into the hole, as shown.

c. Test the cork, sipper and balloon in the bottle. Blow up the balloon to be certain that it is tied air-tight.

d. Steam the inside of the bottle for one minute.

e. Lift the bottle with a towel, stand it upright and quickly insert the cork air-tight. The balloon will expand as the steam cools and condenses to water.

ADVICE: Read the Note in Experience 3.



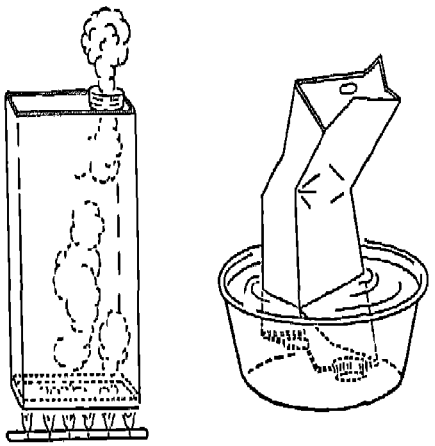
9. Soda Bottle and Tumbler

a. Fill a soda bottle with water and invert an empty tumbler over its mouth.

b. Hold the tumbler and bottle together and invert both. A little water will run into the tumbler.

c. Lift the bottle two inches and hold it steady in this position. Air flows into, and water out of the bottle, but both stop as soon as the water level in the tumbler reaches the mouth of the bottle.

d. Lift the bottle another inch and hold it. Again air flows into, and water out of the bottle, and again both stop when the water level in the tumbler reaches the mouth of the bottle.

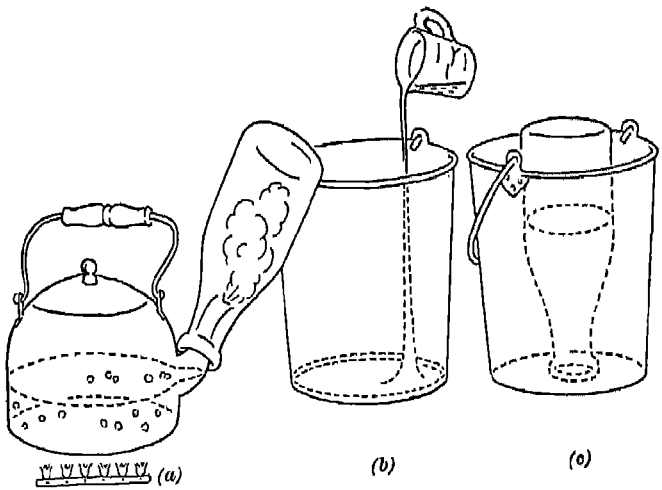


(a) (b)

10. Gallon Can

a. Pour a tumbler of water into a gallon can with a screw cap, place the *open* can on the stove and boil the water until the steam has issued for 1 minute or more.

b. Turn off the gas, screw on the cap, invert the can and place it cap down in a pan or pail of water. The can will collapse.



11. Tea Kettle Steamer

Pour water into a tea kettle until it covers only the lower half of the hole leading into the spout. The steam can then enter the spout.

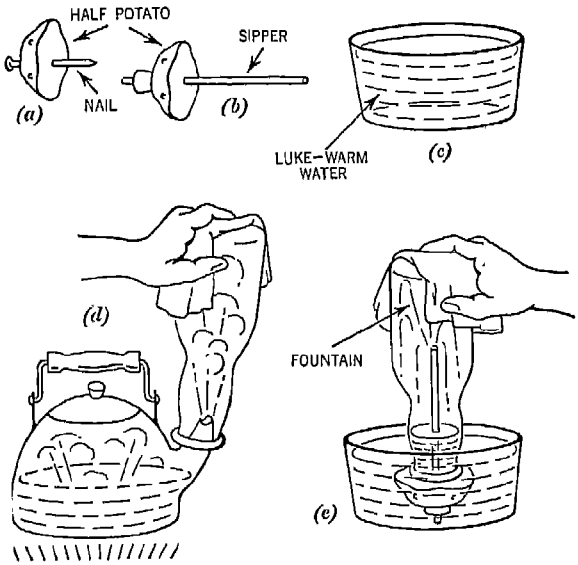
To get water into an upside-down milk bottle.

a. Place the milk bottle over the spout of a tea kettle and steam it inside for 1 minute.

b. Pour six cups of warm water into a large pail.

c. Invert the milk bottle quickly into the pail and the water will run up into it.

ADVICE: Read the Note in Experience 3.



12. A Fountain in a Bottle

Buy a plastic soda sipper at the ten-cent store for five cents; and, if there is a spoon at one end, use a knife with a sawing motion to cut it off.

a. Find a raw potato larger than the mouth of a quart milk bottle, cut it in half, and use a nail to bore through one half a hole just large enough to fit the soda sipper air-tight.

b. Shove one end of the sipper air-tight through a small cork, to prevent it from sliding through the potato, and shove the other end through the half potato.

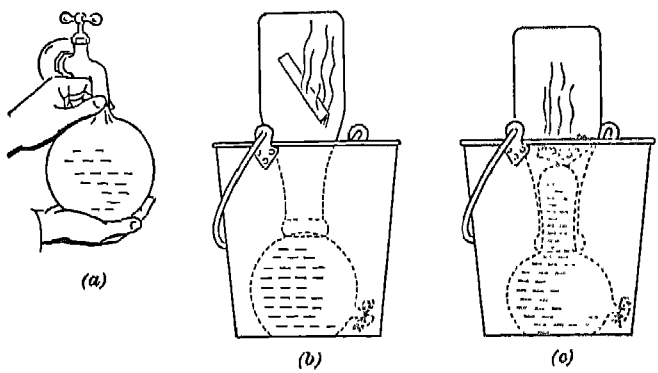
c. Pour three pints of luke-warm water into a saucepan.

d. Steam the inside of a quart milk bottle one full minute.

Turn to page 14

e. Lift the bottle with a cloth, quickly insert the sipper, and then hold the potato air-tight against the mouth of the bottle and invert the bottle in the saucepan. Hold the mouth under water with the sipper above the bottom and you will see a vigorous fountain in the bottle.

ADVICE: Read the Note in Experience 3.

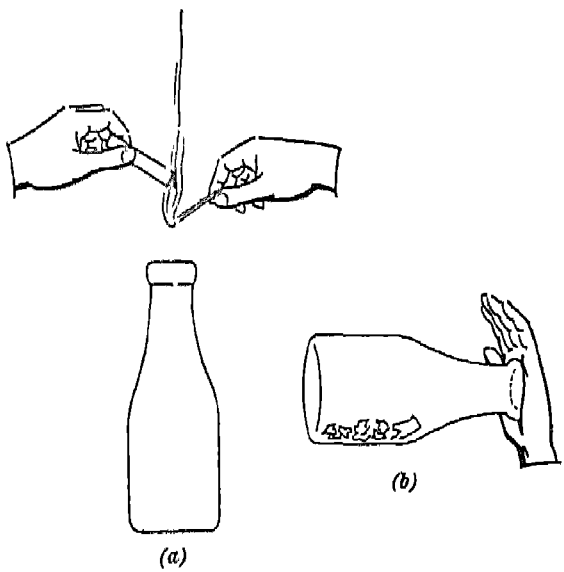


13. Milk Bottle and Water Balloon

a. Fill a large round balloon with about a pint of water and tie it.

b. Place the balloon in an empty pail. Light a folded 4″×4″ piece of newspaper, drop it into a quart milk bottle and quickly press the mouth of the bottle against the balloon.

c. Part of the water balloon will move up into the bottle.

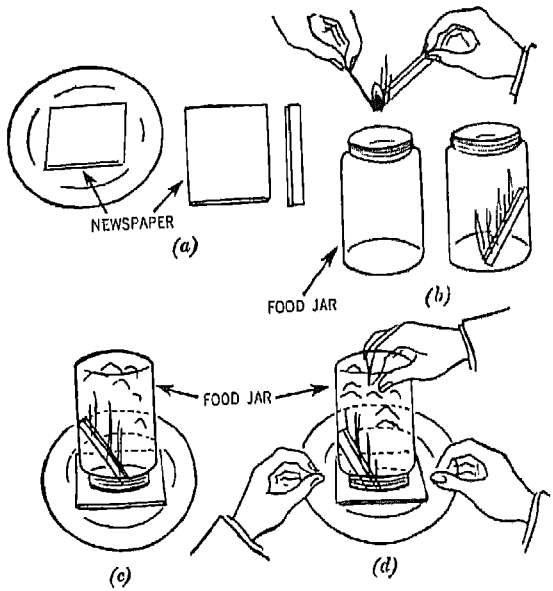


14. Milk Bottle and Palm

a. Fold a 4″×4″ piece of newspaper three times in the same direction and light it at its lower end.

b. Drop it into a quart milk bottle, turn the bottle on its side and press your palm against the mouth of the bottle. You will feel your palm sucked into the bottle.

c. *Fill* the bottle with water to drive out burned air and paper. Empty it to let in fresh air.



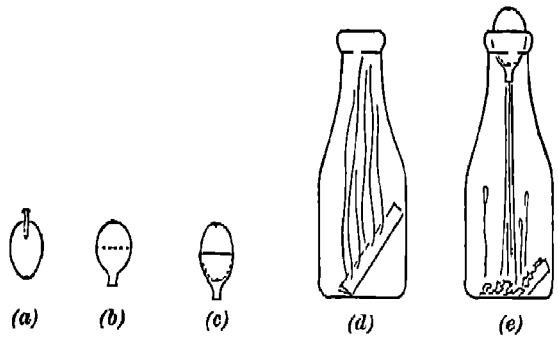
15. The Atmosphere Holds Them Together

a. Fold a whole sheet of a large newspaper again and again until you have sixteen thicknesses about 4″×5″. Place it on a dinner plate, wet it thoroughly and drain off the surplus water. Then take a piece of dry newspaper 4″×4″ and fold it until it is 4″×½″.

b. Light this folded strip at its lower end and drop it it into a wide-mouth food jar.

c. Quickly invert the food jar and press its wide mouth down on the wet newspaper. Hold it down airtight until the air inside cools.

d. Ask a friend to hold the plate down on the table while you try to lift the food jar. You will find it hard to do.



16. To Suck an Egg

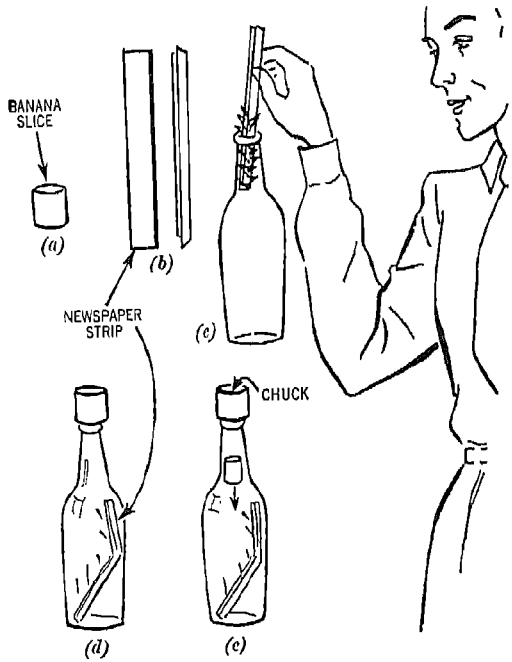
a. Punch a small nail hole through the shell and inner skin at each end of a fresh egg.

b. Find a balloon a little larger than the egg and cut it in halves.

c. Pull the mouth half of the balloon over one end of the egg to serve as a gasket.

d. Fold a 4″×4″ piece of newspaper, light it at the lower end and drop it into a quart milk bottle.

e. Hold the gasket-covered end of the egg air-tight in the mouth of the bottle and the contents of the egg will flow into the bottle.



17. Chuck

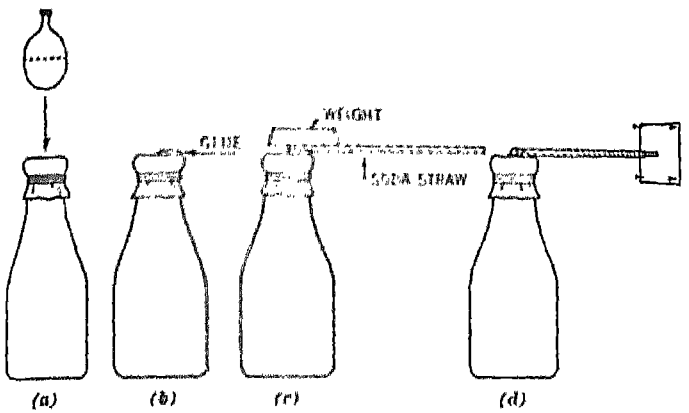
a. Cut a section about 1½ inches long out of an *unpeeled* banana.

b. Cut a strip of newspaper 6 inches long and 1 inch wide. Fold it until it is 6 inches long and ¼ inch wide.

c. Light it at its lower end and drop it into an empty quart bottle from pop or vinegar.

d. When the flame begins to go out, hold the banana section air-tight on the mouth of the bottle.

e. You will soon see and hear the pulp of the banana section slide into the bottle with a "chuck" sound.



18. Barometer

a. Fasten the bottom half of a round balloon air tight over the mouth of a quart milk bottle by means of a doubled rubber band.

b. Put some glue on the balloon rubber from middle to one side.

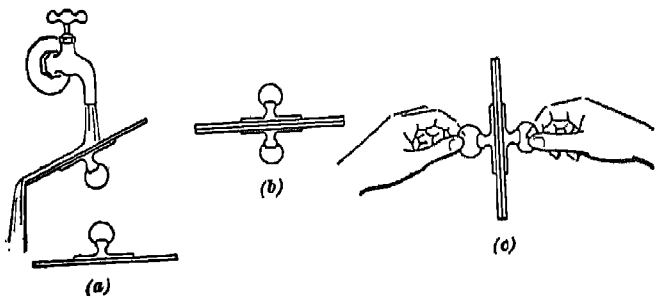
c. Put one end of a soda straw in the glue, being sure that the end of the straw is at the middle of the rubber.

Put a light weight on the straw and rubber until the glue holds.

d. Put a match stick into the other end of the straw to serve as a pointer. Place this barometer with its pointer near a piece of paper pinned to the wall.

Mark the position of the pointer each day. It rises when the atmospheric pressure rises, and vice versa.

This barometer is accurate only when its temperature is constant.



19. Two Sink Stoppers

a. Wet the bottom of two sink stoppers.

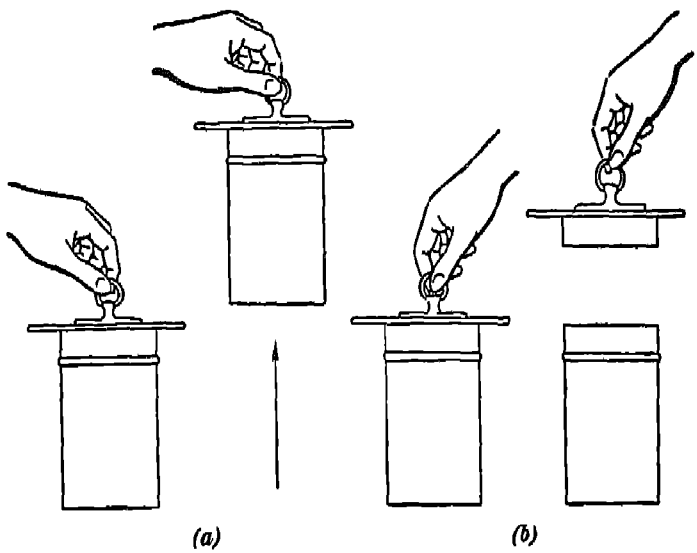
b. Press the bottoms together to drive out the air between them.

c. Try to pull the stoppers apart. You will find you cannot do it without tearing the rubber.

A sink stopper is a flat rubber disk about six inches in diameter which costs five or ten cents. Buy two, and be sure:

1. That they are flat all over the bottom.
2. That they have a rubber knob at the *center* of the upper surface.

Make a horizontal hole through this center knob and insert a metal ring or stout cord for a handle.

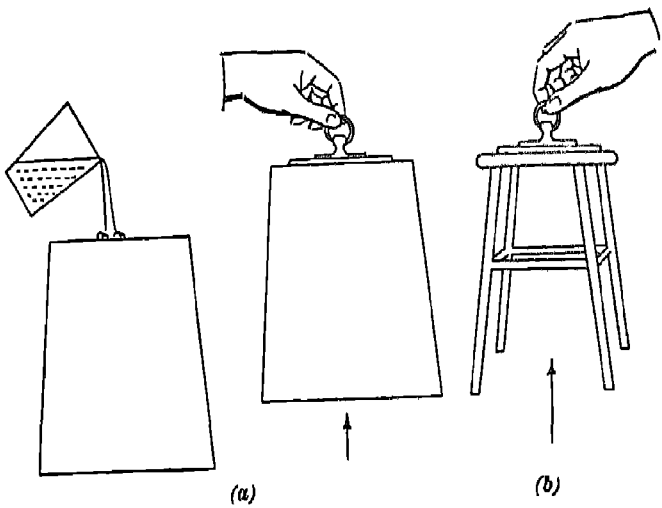


20. Sink Stopper and Coffee Can

a. Fill an uncovered 1 lb. coffee can with water, then press a sink stopper down on the water and lift it. You will lift the can and water.

b. Press the cover down tight on the can and wet it, then press down the sink stopper, hold the can and lift the stopper.

You will remove the cover easily.

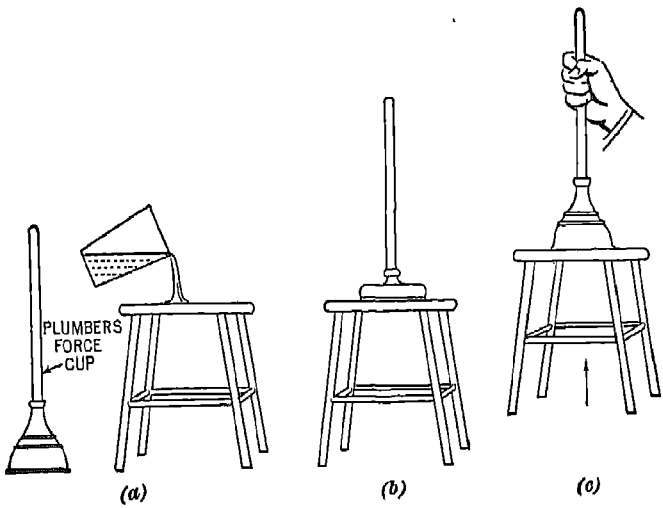


21. Sink Stopper, Pail and Stool

a. Wet the smooth bottom of a pail, press down the sink stopper and lift it.

You will lift the pail also.

b. Wet the smooth seat of a stool or chair, press down the sink stopper and lift it. You will lift the stool or chair also.



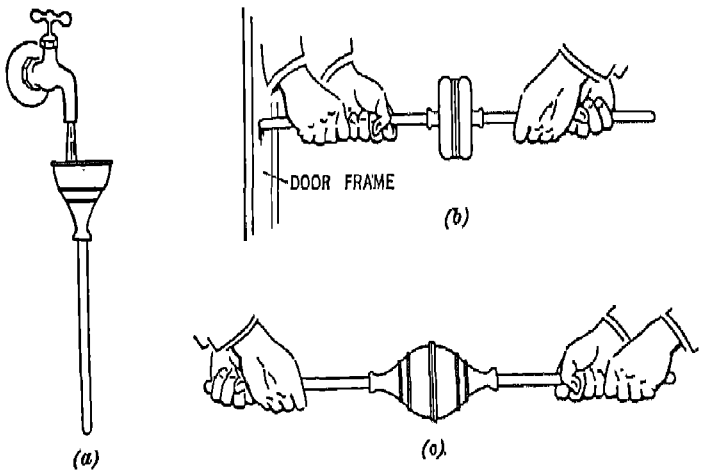
22. Plumber's Force Cup

a. Spread water over the *smooth* wooden seat of a stool.

b. Press the plumber's force cup down on the seat until most of the air in the cup is expelled. Lift the cup by its handle and the stool will follow.

A plumber's force cup is a rubber half sphere with a handle. It costs 10 to 25 cents.

Buy two and be sure that the bottom rim of each is heavy and an inch wide.

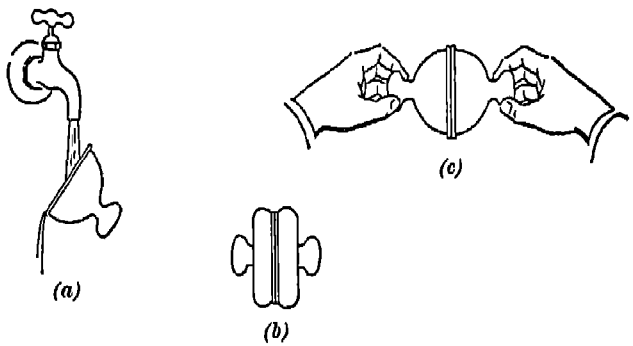


23. Two Plumber's Force Cups

a. Wet the bottom rim of two force cups.

b. Empty the cups and put them together. Then hold one handle against a door frame, or other solid support, while a friend shoves the other handle in hard to force most of the air out of the cups.

c. If you now try to pull the cups apart, you will find it hard to do.



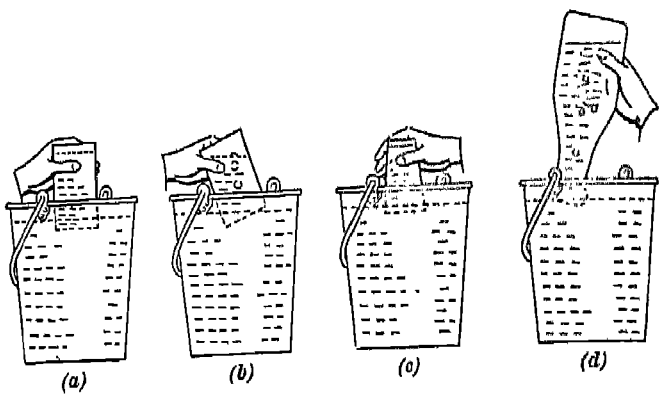
24. Suction Cups

a. Wet the bottom edge of each suction cup.

b. Press the cups together to expel the inside air.

c. Try to pull them apart.
You will find it hard to do.

Suction cups three inches in diameter are sold as coat hangers. They cost ten cents each.



25. Coffee Can, Tumbler and Milk Bottle

a. Fill a coffee can with water and raise it bottom up but keep its mouth under water.

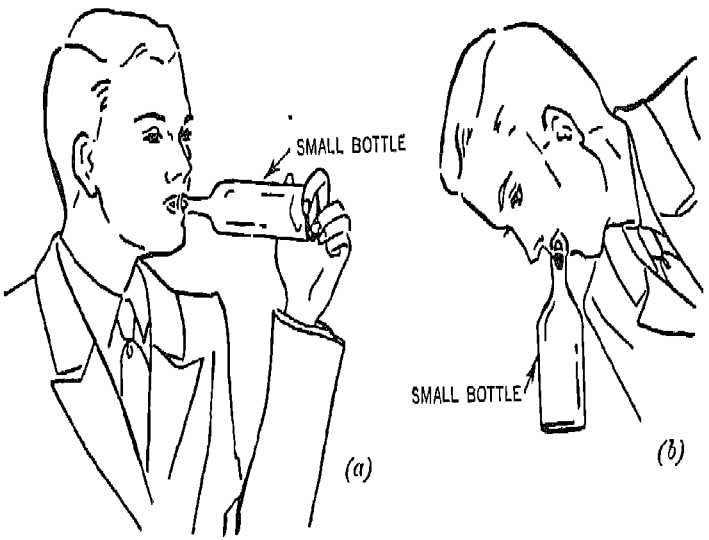
The can will feel heavy.

b. Let in air a little at a time.

The can will feel lighter and lighter.

c. Repeat *a.* and *b.* with a tumbler

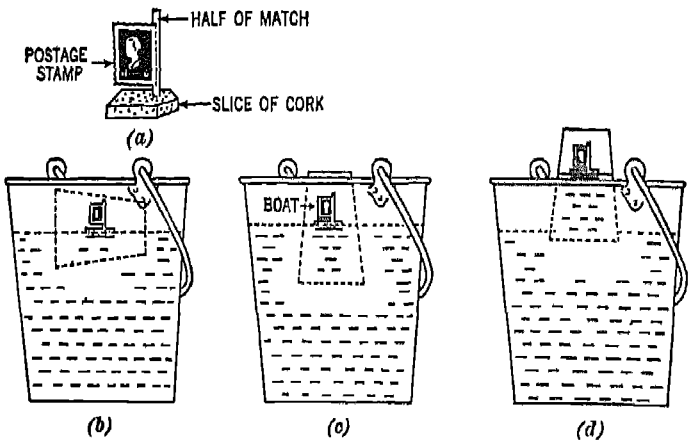
d. Repeat *a.* and *b.* with a milk bottle.



26. The Atmosphere Holds Them Together

a. Suck air out of a bottle.

b. Close the bottle with your tongue and you will find that the bottle clings to your tongue.



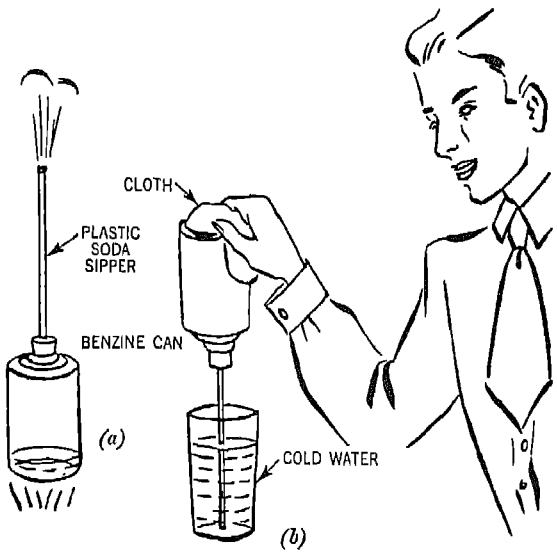
27. To Raise a Boat

a. Make a small boat from a slice of cork, with a half match for a mast and a postage stamp for a sail.

b. Float the boat, then put a tumbler sidewise over it and slowly turn the tumbler bottom up with the boat inside.

c. Raise the tumbler but keep its mouth under water.

The boat will rise, with the water in the tumbler, and float above the water level in the pail.

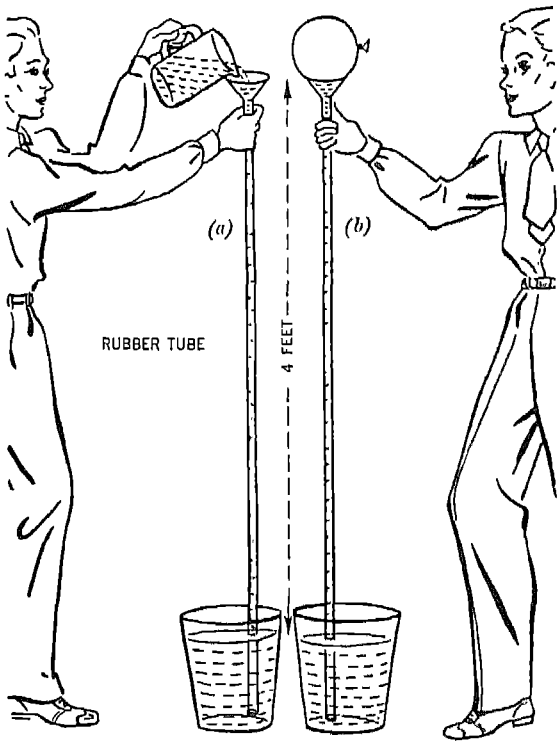


28. The Can Drinks the Water

a. Find an empty can similar to those used for benzine. Find a cork for it and bore a hole through the cork just large enough to hold a plastic soda sipper air-tight. Pour a half-cup of water into the can, insert the cork and boil the water.

b. When the steam is coming out strong, put out the fire, lift the can with a cloth, invert it and dip the plastic soda sipper into a tumbler of water.

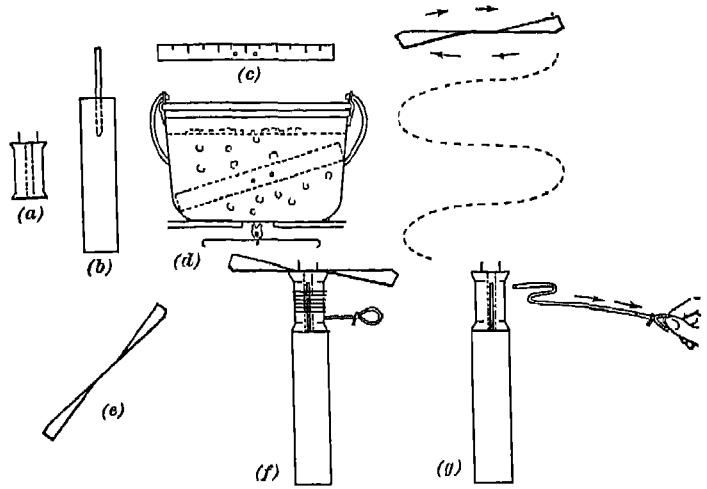
You will see the water disappear into the can with a gurgling sound.



29. Suction

a. Shove the stem of a small household funnel into one end of the rubber tube from a bath spray. Put the other end of the tube into a pail of water. Pour water into the funnel until you are certain you have driven the air out of the tube; then pinch the tube when the funnel is full of water.

b. Hold an air-filled toy balloon down air-tight on the mouth of the funnel and unpinch the rubber tube. You will see the balloon held firmly in the mouth of the funnel by suction.



30. To Make a Helicopter

a. Drive two small nails into one end of a spool, on opposite sides of the hole and equal distances from it. Cut off the heads of the nails.

b. To make a support, drive a large nail into one end of a piece of wood about 4″×1″ and cut off its head.

c. Buy a 6″ celluloid ruler and bore holes at equal distances from its center, *to engage the nails in the spool. Make the holes a little* larger than the nails.

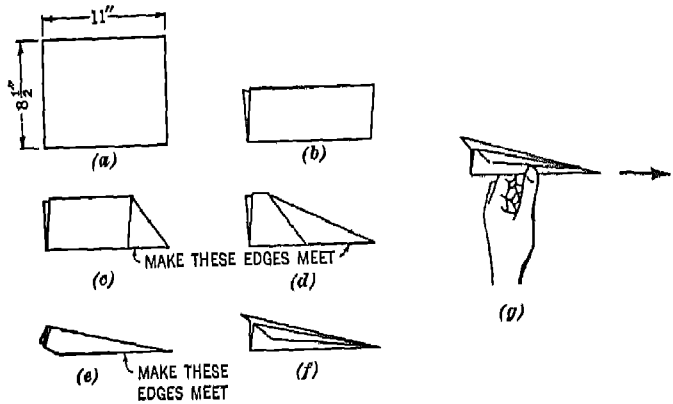
d. Put the ruler into boiling water until the celluloid is soft.

e. Take it out and bend the ends of the ruler in opposite directions to make a propeller. Hold them until the celluloid cools and hardens.

f. Wind a cord around the spool in such direction that when it is unwound it will turn the propeller in the right direction to rise. Put the propeller on the spool and the spool on the support.

g. Hold the support in one hand and pull the end of the cord hard with the other to twirl the spool.
The propeller will spin and rise to a considerable height.

NOTE: To make propellers out of cardboard: Cut strips 6″×1″. Wet them, bend them into propeller shape and let them dry in this shape over night. The large nail must be shorter than the spool.



31. Dart

Make a paper dart as follows:

a. Find a piece of writing paper about 11"x8½".

b. Fold it lengthwise down the middle.

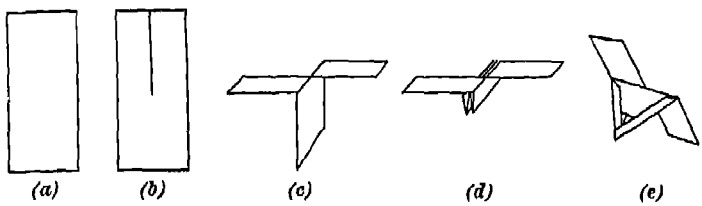
c. Fold back each corner at one end and make the edges meet.

d. Fold back the same ends again and make the edges meet.

e. Fold back the same ends again and make the edges meet.

f. Lift the wings until they are horizontal.

g. Throw the dart with the point forward.
It will sail a long distance.



32. Autogyros

a. Cut pieces of paper about 6″x3″.

b. Cut them in half lengthwise for 3″.

c. Fold the wings in opposite directions.

d. In some, fold up the tail over and over.

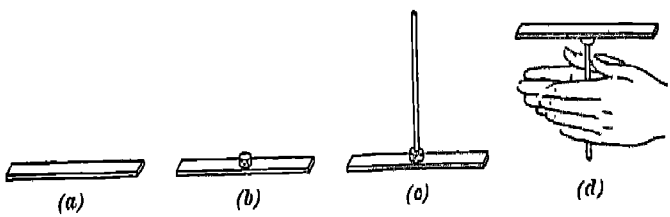
e. In others, fold in the corners of the tail twice.

Stand on a chair, hold them above your head and let them fall.

They will spin to the floor without turning over.

Go upstairs and throw them out of a window.

They will spin to the ground without turning over, and sometimes they will soar to great heights in upward air currents.



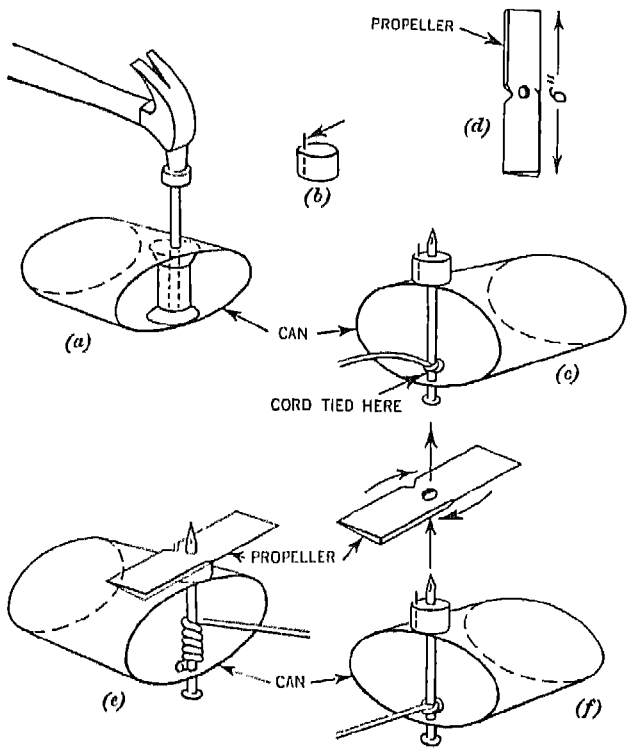
33. An Autogyro

a. Cut a strip of cardboard about 7″x¾″.

b. Cut a half inch slice of a small cork and glue it to the exact middle of the strip.

c. Sharpen the *round* stick of an all-day-sucker and glue it into the exact center of the cork.

d. Twirl the stick between your hands and release it. The autogyro will spin slowly to the floor without tipping.



34. You Make Another Helicopter

a. Cut both ends out of a small soup can, place a spool in the can near one end and use a long nail to punch a hole through each of the opposite sides of the can. Then enlarge the holes until the nail turns easily.

b. Cut a slice of cork about 1½ inches in diameter and 1 inch thick. Shove a thin nail into the cork near one side and file it off about ½ inch above the cork.

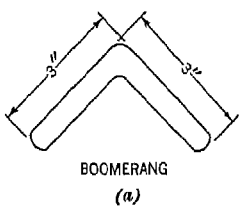
c. Push the long nail up through both holes, and drive it up through the middle of the cork until it projects about ½ inch. Tie a stout cord firmly to the nail inside the can.

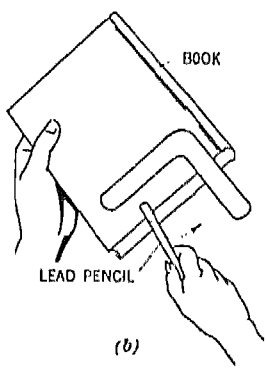
Turn to page 36

d. Cut a strip of wood 6 inches long, 1 inch wide and ¼ inch thick. Bore a hole at its middle larger than the large nail and cut a notch to fit the small nail loosely. Then carve the wood into a propeller.

e. Wind the cord on the nail in such a direction that it will lift the propeller when it unwinds.

f. Hold the can and pull the cord hard, and you will see the propeller rise to a great height.



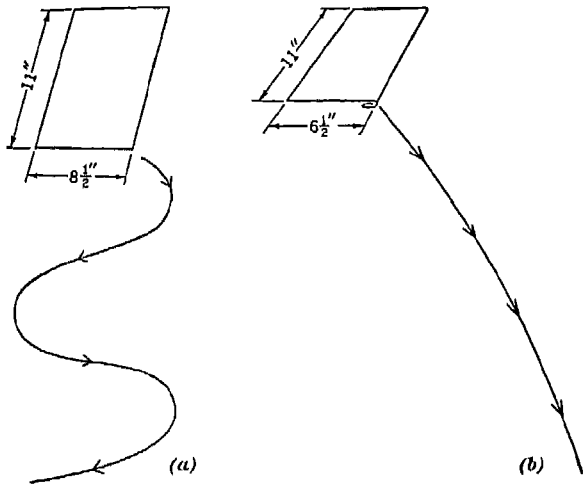


35. Boomerang

a. Cut a boomerang out of smooth, stiff cardboard with the arms about three inches long and 1 inch wide.

b. Place it on a book, point the front edge of the book upward and strike one arm with a lead pencil in such a way as to make the boomerang spin.

The boomerang will sail away with a spinning motion and return to your feet without turning over.



36. Glider

a. Hold a large sheet of writing paper 11″×8½″ above your head with both hands and let it go.

It falls in an irregular manner and may turn over.

b. Now fold one long edge back exactly one inch; then fold it over another inch.

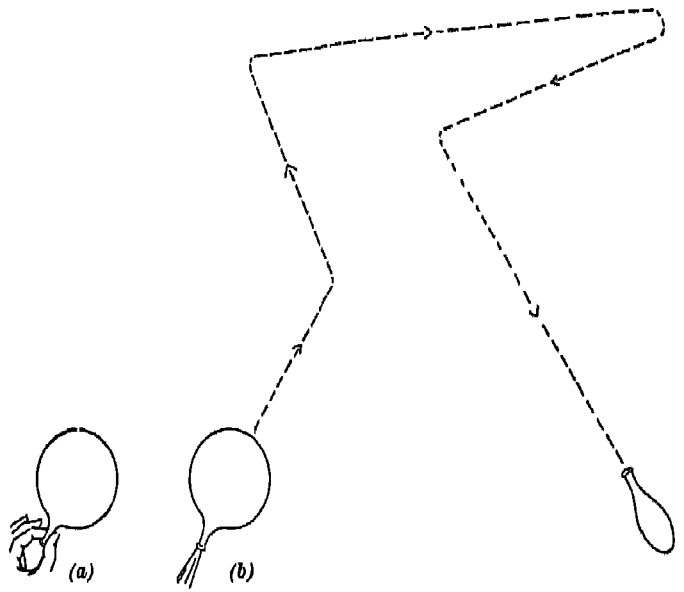
Hold the paper above your head with both hands with the folded edge under at the front.

Give it a gentle push—do not throw it. It will glide like an air plane wing without turning over.

Fold the edge over a third inch and repeat. The sheet will glide without turning over.

Fold the edge over a fourth inch and repeat. The sheet will glide without turning over.

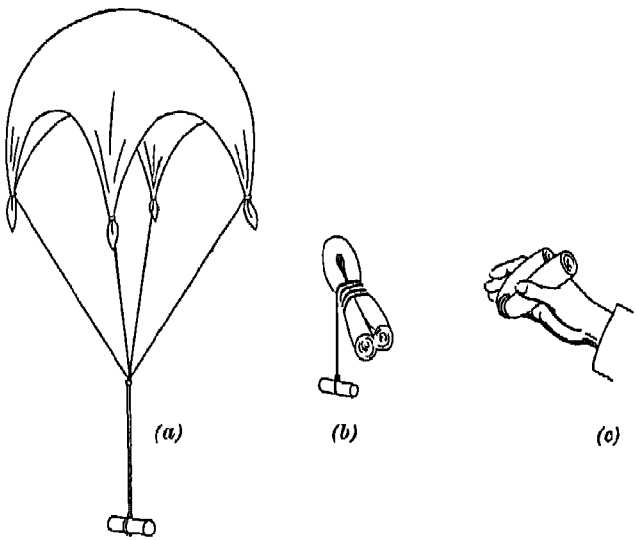
Fold the edge over a fifth inch and repeat. The sheet will drop without turning over but it will glide very little, if at all.



37. Rocket and Jet Airplane

a. Blow up a round balloon and pinch its neck to keep in the air.

b. Point the round end upward and release the neck. The balloon will dart about in a lively manner until deflated. This illustrates the principle of the rocket and of the jet airplane.

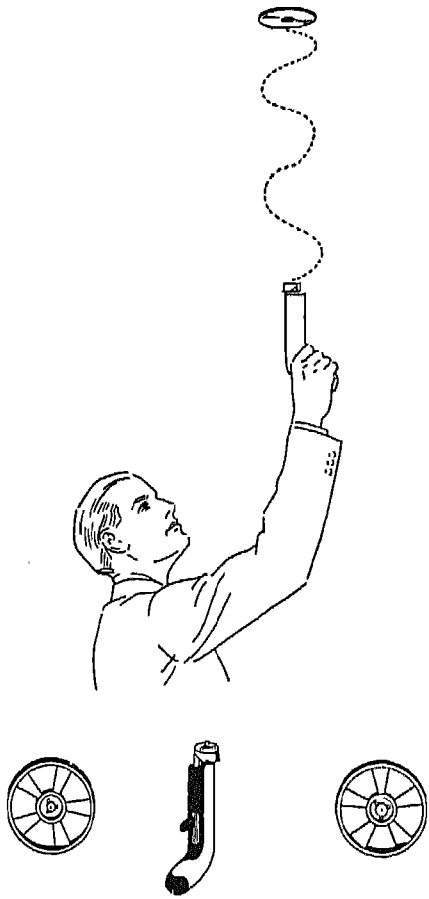


38. Parachute

a. Tie a string to each corner of a large handkerchief and tie the four equal strings to a weight.

b. Fold the handkerchief and wind the strings around it.

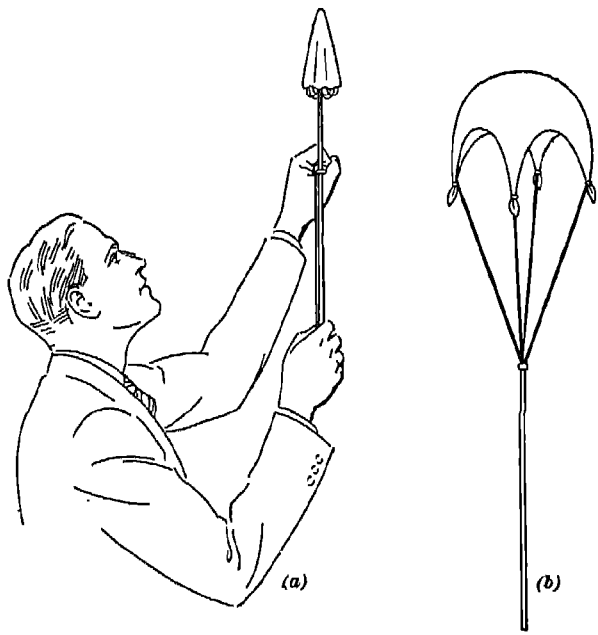
c. Fold the handkerchief again, around the weight and throw the bundle high into the air out of doors. It will open out and float down slowly.



39. Helicopter

This helicopter is called Shoot-a-plane. It spins and rises straight up into the air. It costs thirty-five cents.

Sometimes you can find other helicopters for sale for ten cents.

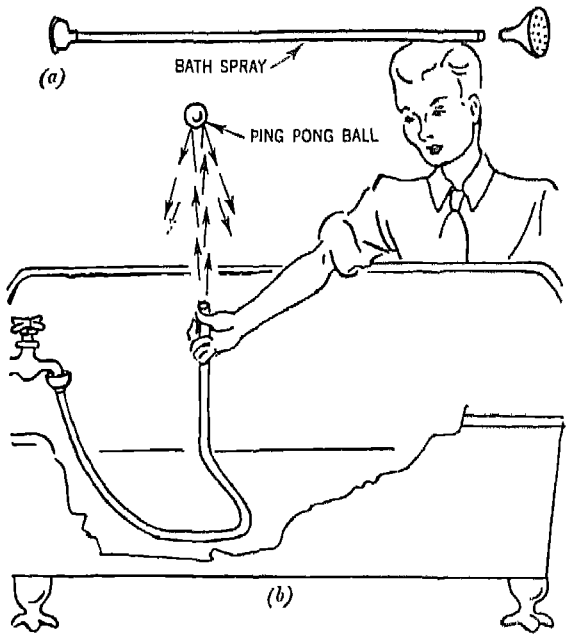


40. Parachute

a. Place one end of the guide stick at the center of the cloth. Put the other end through the hole in the catapult and on the rubber band. Pull the guide stick and band downward ten or twelve inches and shoot the stick *straight upward.*

b. The parachute will rise to a considerable height and float down slowly.

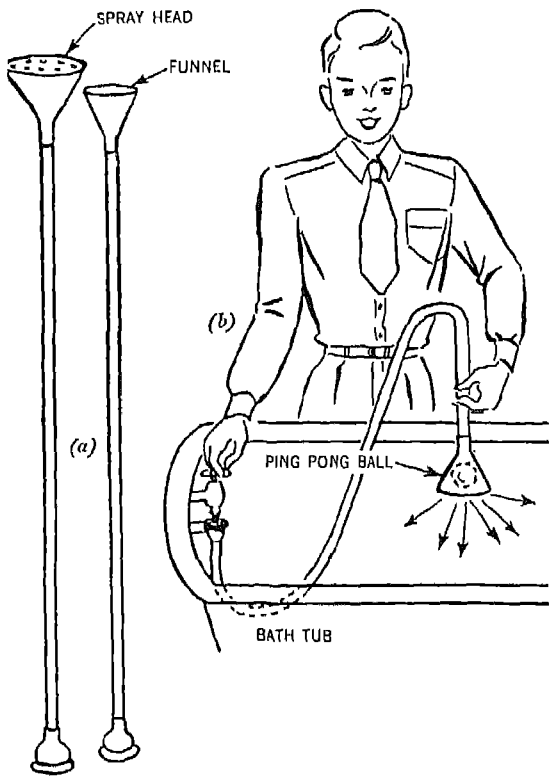
NOTE: Remember you must shoot *straight upward.* This parachute costs 10 cents.



41. Bouncing Ball

a. Remove the spray head from a bath spray.

b. Attach the tube to a faucet, turn on the water, hold the end of the tube upright, pinch the end slightly and place a ping-pong ball in the vertical water stream. You will see the ball bounce up and down as long as you hold the stream truly vertical.

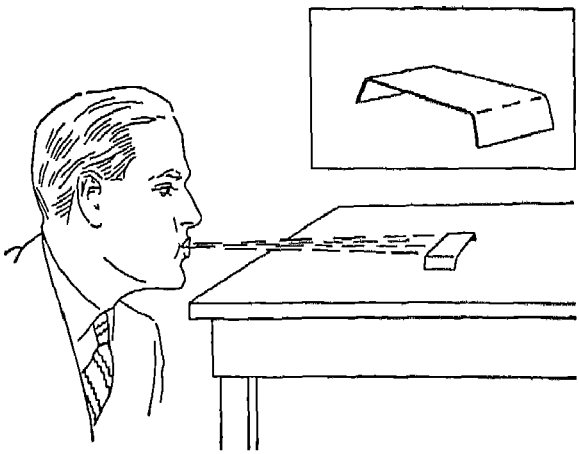


42. The Ball Remains in the Funnel

a. Replace the spray head of a bath spray with a household funnel.

b. Attach the tube to a faucet. Hold the funnel as shown, turn on the water and shove a ping-pong ball up into the funnel as far as you can.

You will find that the ball will remain in the funnel.



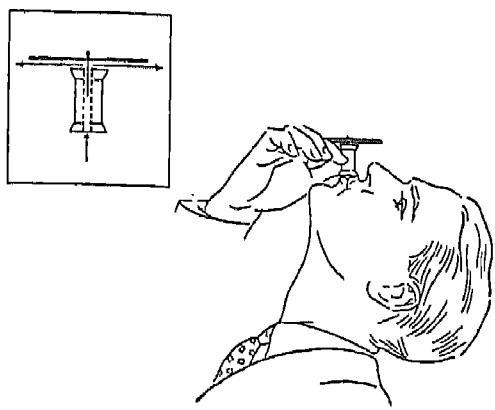
43. You Cannot Blow It Over

Cut a piece of writing paper about 8″×4″ and bend down each end 1 inch.

Place the paper on the table and try to blow it over by blowing hard under it.

The harder you blow the tighter it clings to the table.

Why? See page 209.

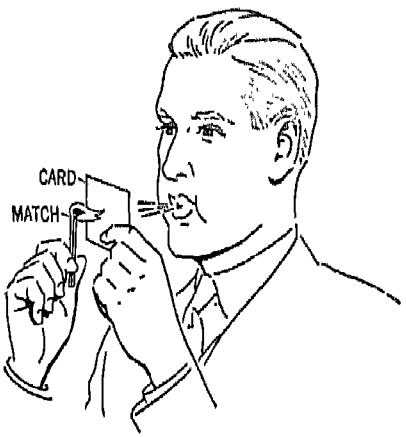


44. You Cannot Blow It Off

Cut a piece of cardboard about 3″×3″, put a pin through its middle point and put the pin in the hole of a large spool.

Bend your head back and blow hard into the hole of the spool, to blow the card off.

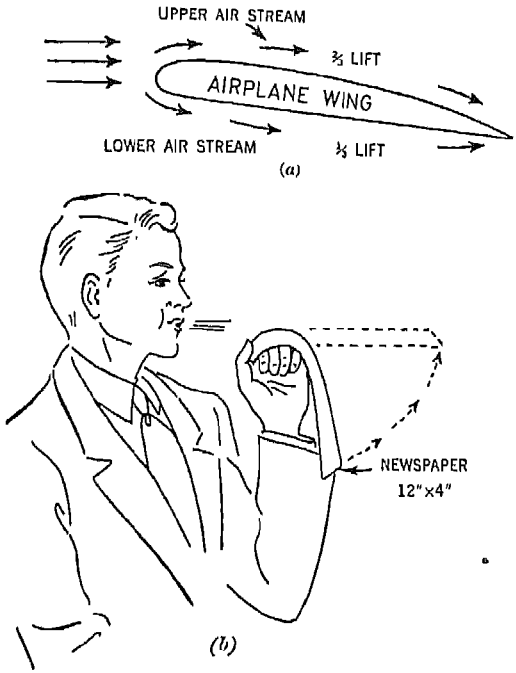
The harder you blow the tighter it clings to the spool.



45. You Blow the Flame *Toward* You

Hold a lighted match behind a card two inches wide and blow hard against the card.

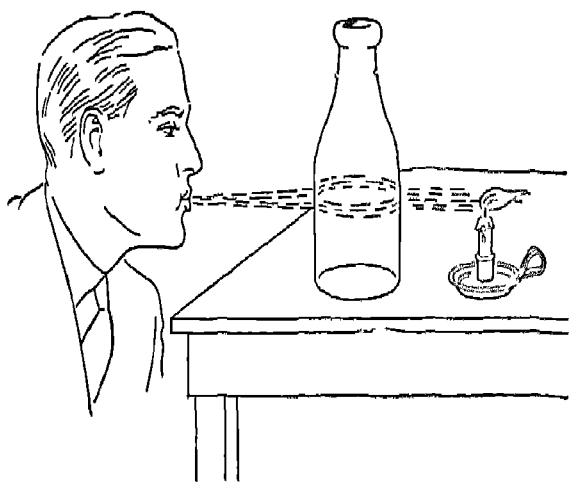
The flame will move *toward* you instead of away from you.



46. Airplane Wing

a. The air stream *over the curved* top of the wing causes about *two-thirds* of the lift on the airplane wing. The air stream *below* the wing causes only about *one-third* of the lift.

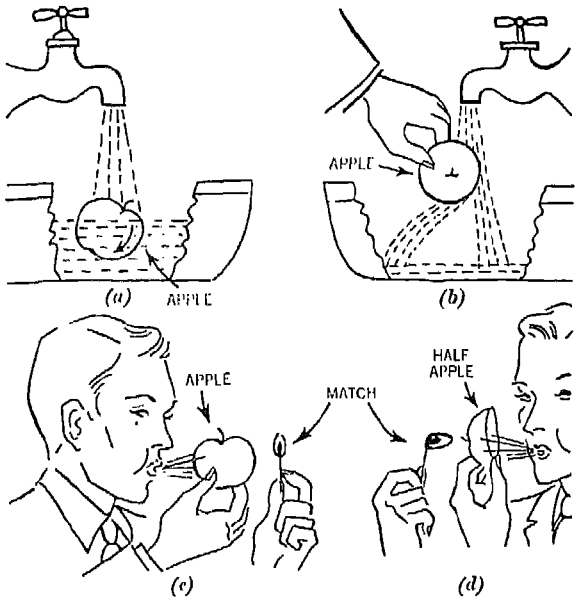
b. To show the lift of an air stream over a curved top, cut a piece of newspaper about 12″×4″, curve it over the back of your hand and hold the near end with your thumb. Blow over the curved top and your air stream will cause the paper to rise.



47. You Appear to Blow Through a Bottle

Arrange the milk bottle and lighted candle or match as above.

Blow hard against the bottle and you will blow out the flame.



48. Halloween Party

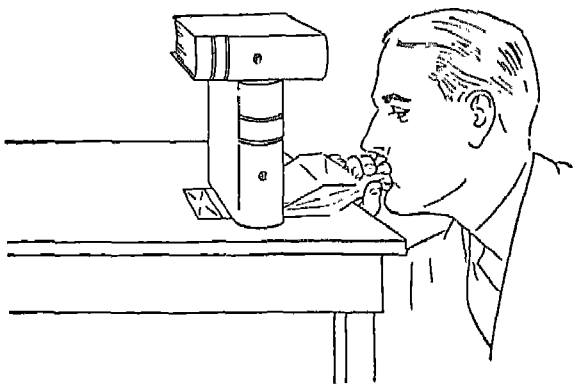
a. Float an apple on water under the stream from an open faucet and you will see it held by the water stream.

b. Hold the apple half way in the water stream and you will see part or all of the stream cling to the apple and bend toward you.

c. Hold a lighted match two inches behind an apple and blow against the near side, and you will blow out the match.

d. Hold a lighted match two inches behind the curved side of half an apple; then blow against the flat side and you will blow the flame *toward* you.

Compressed Air and Expanded Air

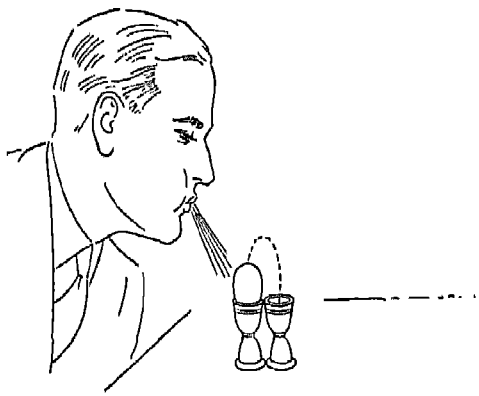


49. To Lift a Weight With Compressed Air

Place two heavy books on an empty paper bag as illustrated.

Blow hard into the bag to inflate it and you will topple the books.

Why? See page 210.

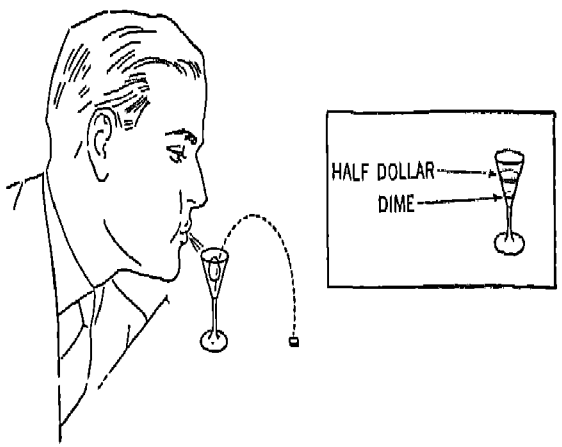


50. Egg Trick

Arrange two egg cups as above.

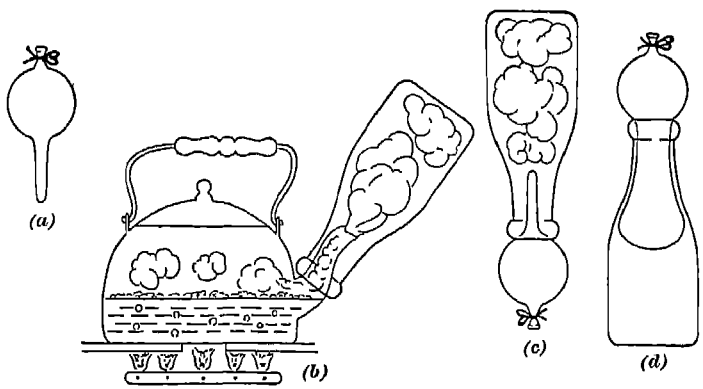
Place an egg in the near cup and blow down hard at its near side.

You will blow the egg over into the other cup. You had better use a hard-boiled egg, which will not spill if broken, or use a thick tablecloth.



51. You Lift the Lower Coin

Place a half dollar and a dime in a small V-shaped wine glass. Blow hard at one edge of the half dollar and the *dime* will fly out.



52. Milk Bottle and Long Balloon

a. Blow up a long balloon until it is only half expanded and tie it so.

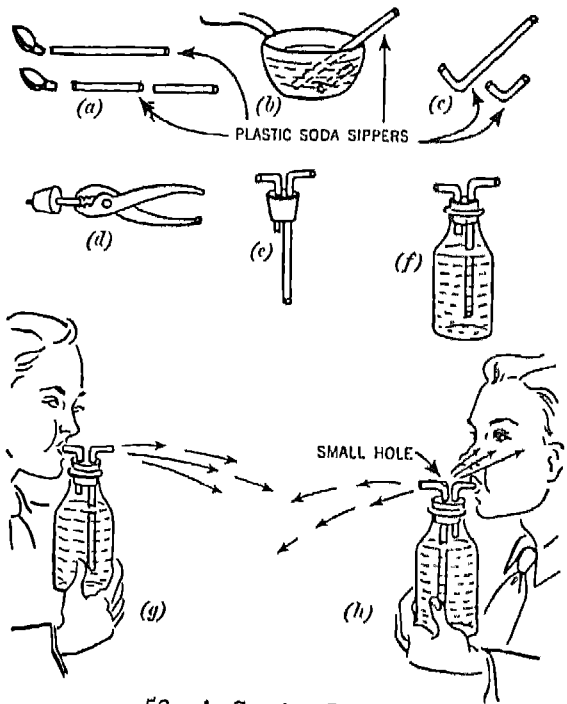
b. Steam the inside of a quart milk bottle for one minute.

NOTE: Be sure that the water in the tea kettle covers not more than the lower half of the hole leading into the spout. The steam can then pass through the upper half into the spout.

c. Quickly put the unexpanded part of the balloon into the bottle and hold the expanded part against the mouth to keep out air.

d. The air in the balloon will expand the balloon into the bottle as the steam condenses.

ADVICE: Read the Note in Experience 3.



53. A Squirt Bottle

a. At the ten-cent store buy two plastic soda sippers for five cents each; if each has a spoon at one end, use a knife with a sawing motion to cut the spoon off. Then cut one sipper in half.

b. Place one half-sipper and the long sipper in boiling water until they are soft.

c. Then make a right-angle bend in the long sipper one inch from one end, and a similar bend in the half-sipper at the middle.

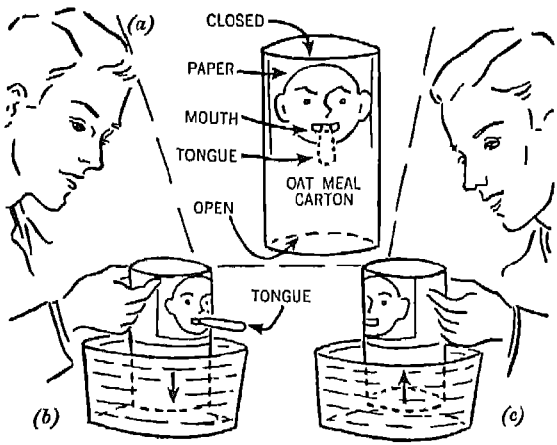
d. Find a six-ounce bottle with a cork and use a red hot nail or gimlet to bore through the cork two holes to fit the sippers air-tight.

e. Shove the sippers into the holes.

f. Fill the bottle with water and insert the cork air-tight.

g. Blow hard into the short sipper and you will make a fine stream.

h. *Trick Bottle.* Use a thin red hot nail to bore a secret hole in the outside of the bend in the long sipper. Cover this hole with a finger while you produce a stream for a friend. Then let him try it, and tell him to blow hard. He will *blow water into his face.*



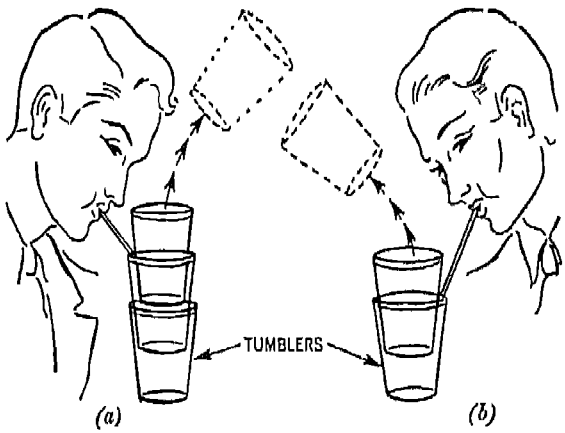
54. Impudence

a. Find an empty oatmeal carton made of cardboard. Draw a face on a 2½″×2½″ piece of white paper and paste the paper on the side of the carton near the closed end. Cut through the paper and cardboard to make a mouth one inch wide and three-quarters of an inch high. Cut a red tongue, two inches long and a little less than one inch wide, out of thin red cloth or thin red rubber from a toy balloon. Glue one end of the tongue to the *inside* of the *upper lip* of the mouth.

b. Fill a saucepan with water to a depth one inch below the mouth; then sink the open end of the carton *rapidly* into the water and you will see the little man stick out his tongue.

c. Lift the carton out *rapidly* and you will see him draw his tongue in again.

Remember you must move the carton down and up *rapidly*.



55. Compressed Air Lifts the Tumblers

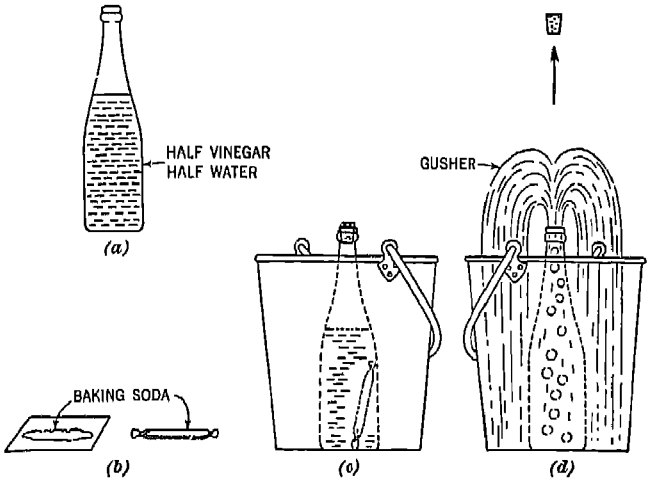
a. Stack three similar *light* tumblers, as shown, and blow down hard between the two upper tumblers.

You will lift the top tumbler.

b. Repeat with the two remaining tumblers and again you will lift the top tumbler.

NOTE: The tumblers *must* be light. Use a *thick* tablecloth to prevent the tumblers from breaking.

Compressed Gas



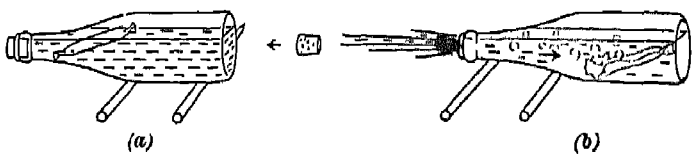
56. A Bottle Gusher

a. Find a cork to fit a 12-ounce soda bottle.
Fill the bottle *to the bottom of the neck only* with a mixture that is half vinegar and half water.

b. Put two level teaspoonfuls of baking soda on a single sheet of toilet paper. Make a thin roll and twist the ends.

c. Drop the roll into the bottle and shove the cork into the bottle firmly, but not too firmly.
Shake the bottle once vigorously to break up the roll, and stand it in an empty pail.

d. The gas produced by the vinegar and baking soda will drive out the cork with a loud pop, and at the same time lift part of the liquid out as a fine white gusher.



57. Cannon Recoil

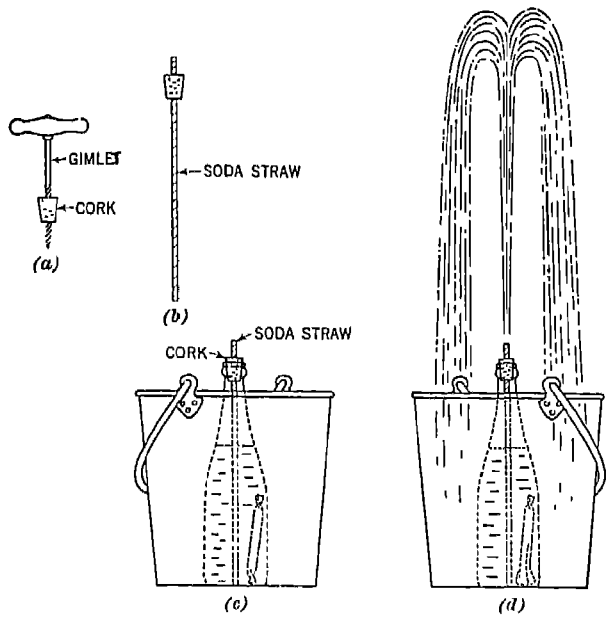
a. Prepare a bottle as in the last experience.

Go outside and prepare to lay the bottle on its side on two *round* pencils on a *smooth surface.*

Insert the baking soda roll, insert the cork, shake the bottle once and place it on the pencils.

b. Soon you will hear a loud pop and see the cork fly one direction and the bottle recoil in the opposite direction.

c. Repeat, but use *hot water* instead of the vinegar and water, and baking *powder* instead of the baking soda.



58. A Fountain

a. Use a gimlet or red-hot nail to bore a hole through a cork which fits a 12-ounce soda bottle.

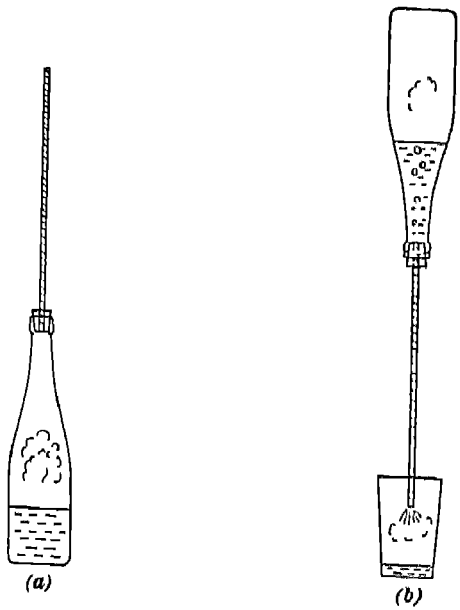
b. Fit a soda sipper air-tight into the hole.

c. Fill the bottle to the bottom of the neck only with a mixture that is half vinegar and half water. Make a roll of two level teaspoonfuls of baking soda. Twist the ends.

Place the bottle in a pail, insert the roll and stopper and shake once to break up the roll.

d. You will see a fine fountain.

e. Repeat, with hot water and baking powder, as in 57*c*.

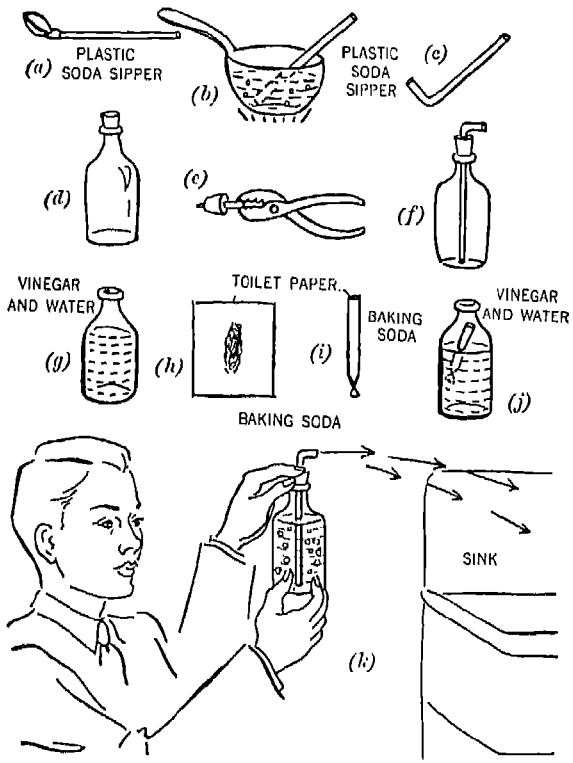


59. Hiccup Bottle

a. Find a cork to fit a 12-ounce bottle and use a gimlet or red hot nail to bore a hole through it, large enough to fit a paper soda sipper. Fill the bottle to a depth of 2″ *only* with *hot* water.

b. Invert the bottle and it will hiccup at regular intervals.

Cut the soda sipper in half and the bottle will hiccup more rapidly.



60. Soda-Acid Squirter

a. Buy a plastic soda sipper; if there is a spoon, cut it off.

b. Place one end of the sipper in boiling water until it is soft.

c. Make a right-angled bend.

d. Find a cork for a 12-ounce bottle.

e. Bore a hole through it just big enough to hold the sipper air-tight.

f. Push the sipper into the cork and test both in the bottle.

g. Fill bottle to bottom of neck with 1:1 mixture of vinegar and water.

h. Put two level teaspoonfuls of baking soda on a sheet of toilet paper.

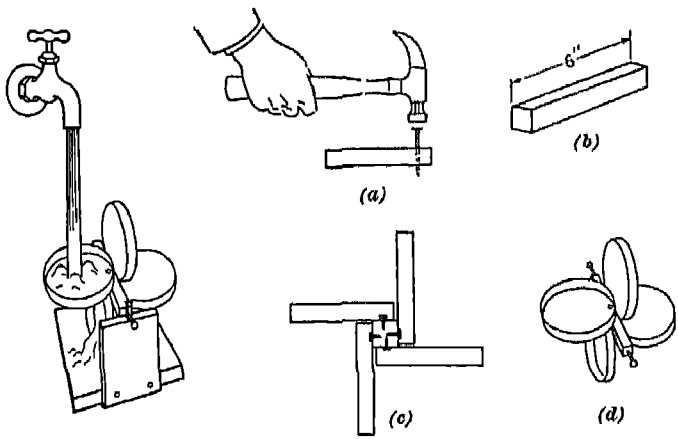
i. Make it into a roll that will go in the bottle and twist one end.

j. Put the roll into the bottle, twisted end first.

k. Insert the cork, hold it firmly and shake the bottle up and down vigorously. You will see a fine stream.

This illustrates the action of a soda-acid fire extinguisher.

Water Wheels and Turbine



61. Water Wheel

Make a water wheel from four coffee can covers, as shown.

How to make it.

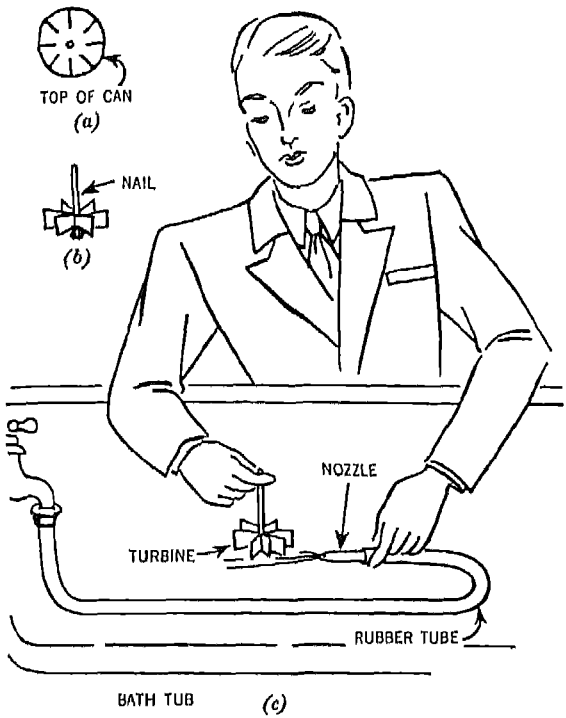
a. Punch a small hole near the edge of each coffee can cover.

b. Cut a *square* piece of soft wood about 6″ long.

c. Tack the covers to the wood.

d. Drive a nail into each end of the wood, for an axle.

e. Mount the wheel on a frame as in the first figure, with each axle between a pair of short nails. It is a powerful water wheel.

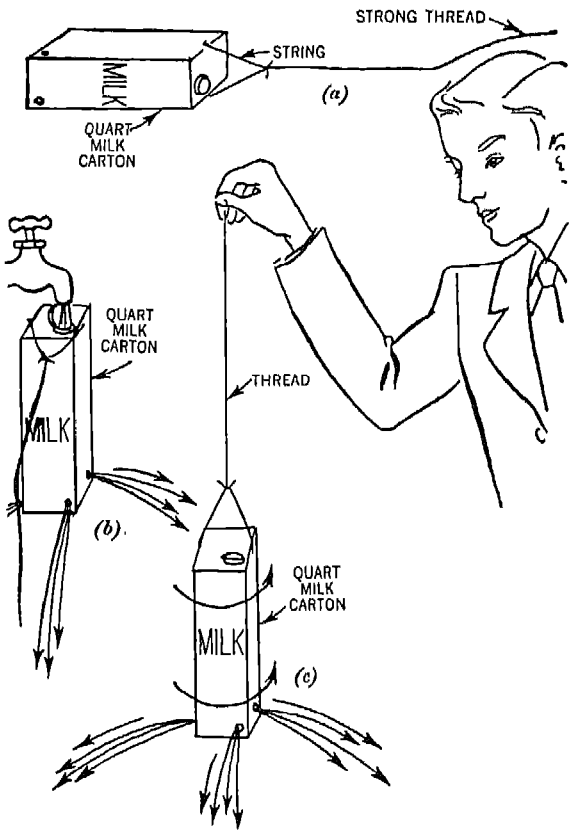


62. A Water Turbine

a. Punch a nail hole at the center of a round tin top from a food can; and make, around the rim, eight equally spaced cuts to within ½ inch of the center hole.

b. Use a pair of pliers to turn the sectors at right angles to make blades; and use a thinner nail, head down, for the axle of the turbine.

c. Attach the rubber tube of a bath spray to a faucet, turn on the water, and direct the stream against the blades from a nozzle or by pinching the end of the tube until the stream is narrow and very fast. The water will spin the turbine rapidly.

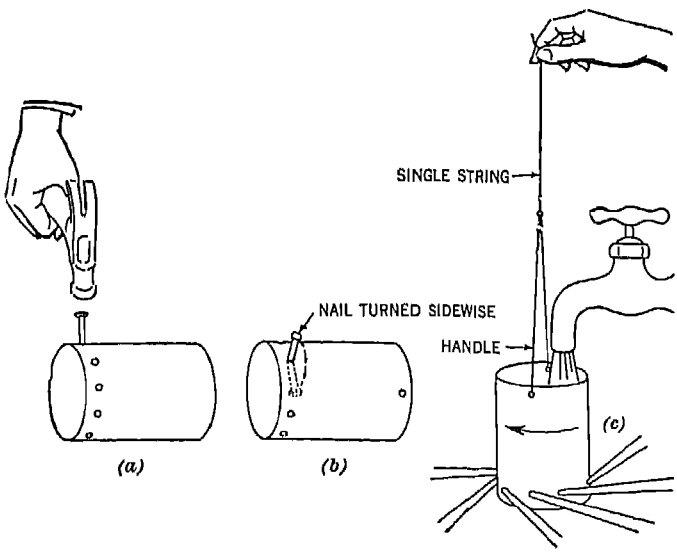


63. Reaction Turbine

a. Find an empty quart paper milk carton, make a handle for it with string and strong thread, as shown, and then use a nail to punch a hole in the lower right-hand corner of each side.

b. Fill the carton with water.

c. Hold up the carton by the strong thread and you will see it revolve rapidly.



64. Reaction Turbine

a. Punch nail holes ½ inch apart all around the side at the bottom of a round can.

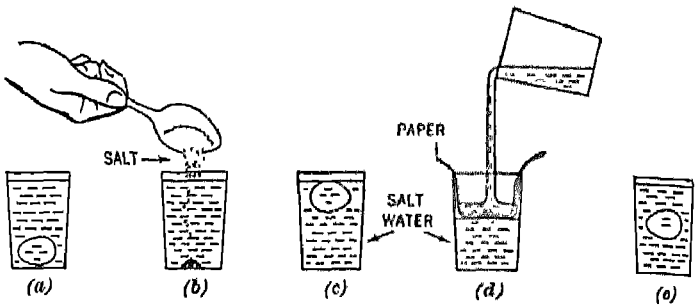
b. Put the nail in each hole again and twist each hole sidewise parallel to the bottom. Twist them all in the same direction so that all will throw the water jets sidewise in the same direction.

c. Punch two opposite holes near the top and tie in a short string for a handle.

Tie a single long string to this handle and support the can under an open water faucet.

The can will turn rapidly until the long string is wound very tight.

Buoyancy of Liquids



65. Egg Submarine

a. Put a fresh egg into a tumbler of fresh water and it will sink to the bottom.

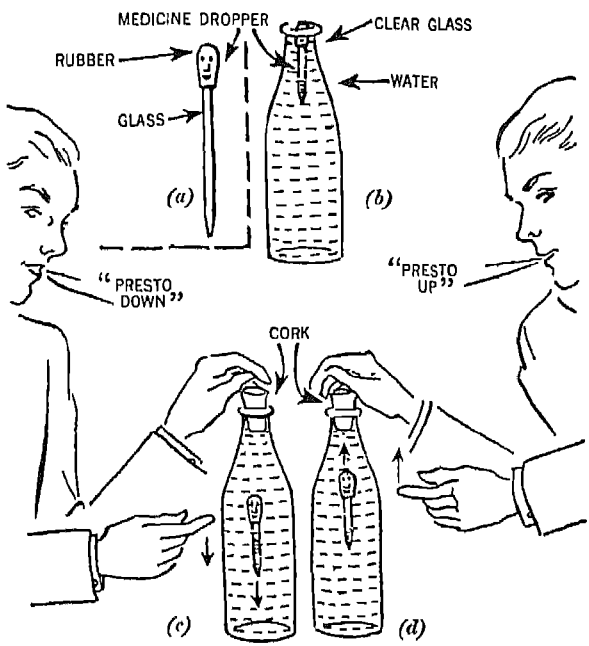
b. Dissolve one heaping tablespoonful of salt in the water.

c. Place the egg in the salt water and it will float.

d. Pour out half the salt water. Bend a strip of paper down on the salt water surface to prevent mixing and fill the tumbler with fresh water. Remove the paper slowly to prevent mixing.

e. Place the egg submarine in the tumbler and it will float half way down.

Why? See page 212.



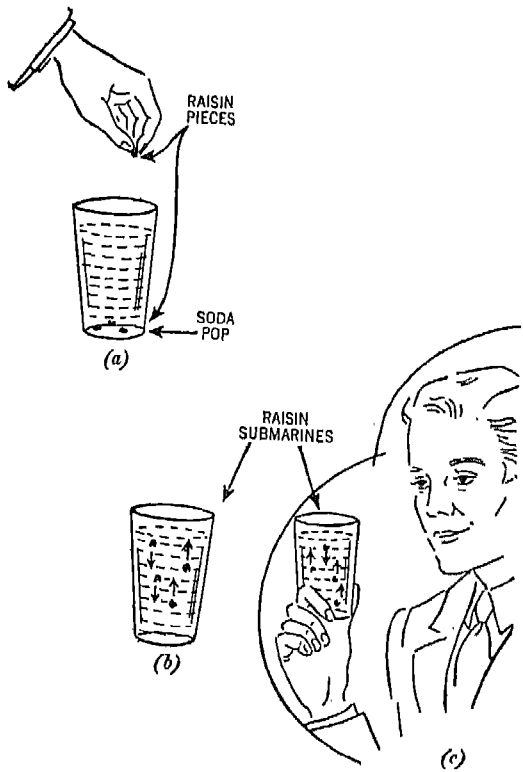
66. Magic Diver

a. Use a pencil to mark eyes, a nose and a mouth on the rubber of a medicine dropper.

b. Fill a clear glass quart pop-bottle with water, and insert the medicine dropper. Be sure the bottle is filled to overflowing.

c. Now move your hand down outside the bottle and say *"Presto Down."* You will then see the little diver sink to the bottom, *if at the same time you secretly insert the cork and press down.*

d. Then say *"Presto Up"* while you raise your hand, and you will see the diver rise to the top, *if at the same time you secretly raise the cork.*

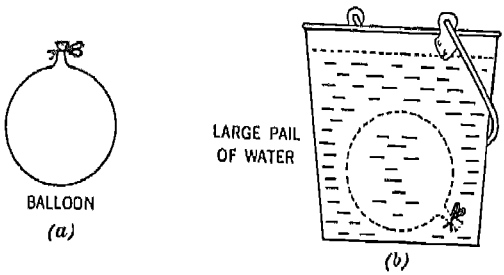


67. Raisin Submarines

a. Cut a raisin into four pieces, and drop the pieces into a tumbler of soda pop. You will see them sink to the bottom.

b. Soon, however, you will see the raisin submarines rise to the surface, then crash dive to the bottom, and rise to the surface again, time after time.

c. Hold the tumbler up to the light and observe the gas bubbles on the submarines.



68. To Feel the Buoyancy of Water

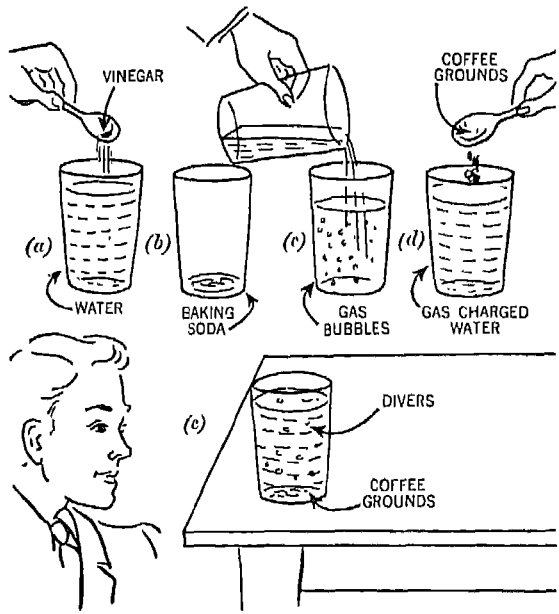
a. Blow up a large balloon *very full* and tie it with a bow knot in the cord so that you can easily untie it.

b. Sink the balloon in a pail of water and you will be surprised to see how hard you must shove down against the lift of the water.

Water wings

Two strong balloons blown up and tied together make excellent water wings.

Real water wings are, in effect, two stout connected balloons in a cloth belt.



69. Pearl Divers

a. Fill a tumbler with water and add three teaspoonfuls of vinegar.

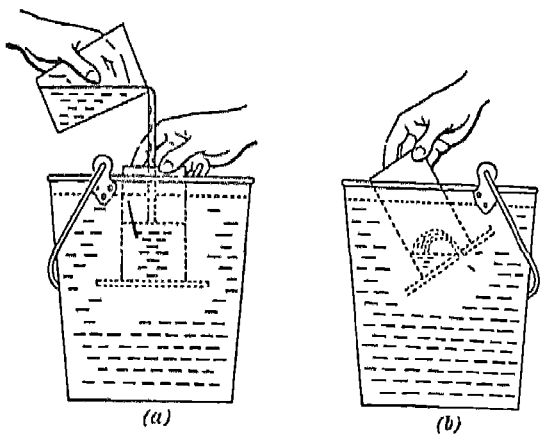
b. Use a dry spoon to put one heaping teaspoonful of baking soda in a dry tumbler.

c. Pour the vinegar water over the baking soda, and you will see millions of bubbles of carbon-dioxide gas (CO_2) rise in the liquid.

d. When the fizzing has stopped, drop a quarter-teaspoonful of coffee grounds into the liquid. (Coffee grounds are the coffee grains left after the coffee has been made and used.)

e. You will see each coffee diver rise to the surface with a pearl, then dive to the bottom and rise to the surface with another pearl, time after time.

NOTE: Each pearl is a bubble of gas.



70. Buoyancy of Water

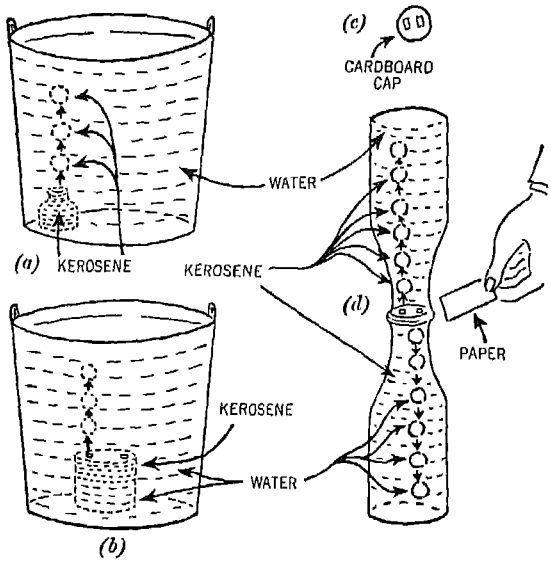
a. Cut both ends out of a food can and cut a piece of cardboard a little larger than the end. Hold the cardboard over one end and sink both under water.

The cardboard will cling to the end and keep the inside dry, when you remove your hand.

Pour water slowly into the can and the cardboard will hold until the water level inside is the same as that outside.

b. Punch a hole in the cardboard near one edge and repeat the experience with the can tilted.

You will see a small fountain.



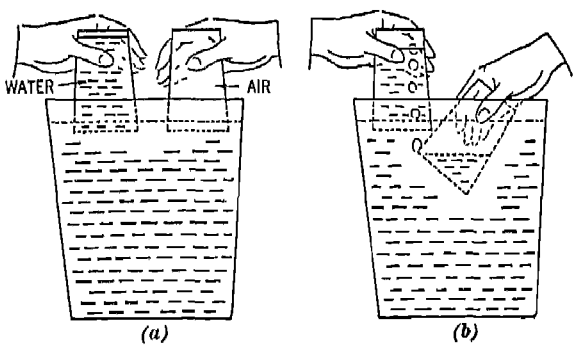
71. Liquid Bubbles

a. Fill an empty ink bottle with kerosene and sink it in a pail of water. Stir the kerosene, if necessary, and you will see many kerosene bubbles rise.

b. Find an empty can from evaporated milk with two ½″ holes in the top. Fill it half with water and half with kerosene and sink it in a pail of water. You will see hundreds of kerosene bubbles rise.

c, d. Cut two holes ½″ by ⅜″ in the cardboard cap of a milk bottle. Fill one quart milk bottle with water and another with kerosene. Put the cap on the water bottle, cover it with a piece of paper, invert the water bottle over the kerosene bottle, and withdraw the paper. Kerosene bubbles rise in the water and water bubbles sink in the kerosene.

The surface tension of the kerosene and that of the water draw these liquids into spherical drops.

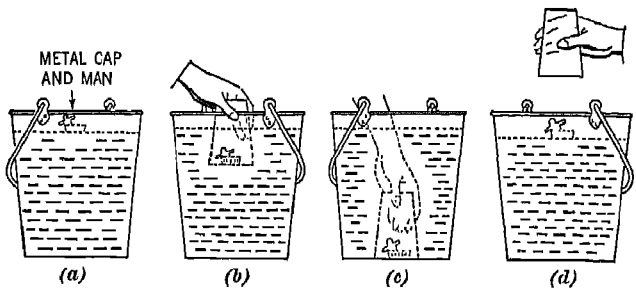


72. You Pour Air Up Hill

a. Arrange two tumblers upside down above a pail of water, one full of water and the other full of air and each with its mouth under water.

b. Tilt the air tumbler down under the water tumbler and the air will pour up hill into the water tumbler.

c. Pour the air back into the original tumbler.



73. Diving Bell

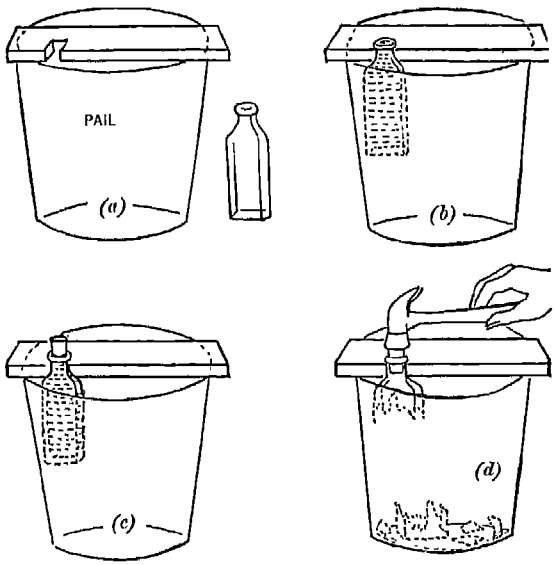
a. Remove the metal cap from a vinegar bottle or soda bottle and float it as a boat in a pail of water. Put in a little man cut out of paper.

b. Place a dry tumbler upside down over the boat and sink the tumbler half way down. The boat will float half way down.

c. Sink the tumbler to the bottom and the boat will rest on the bottom of the pail.

d. Raise the tumbler carefully and the boat will float on the surface again.

A real diving bell resembles a large steel tumbler upside down. It is supplied with air through rubber hose. In it men can work under water on the bottom of a river, lake or ocean.



74. You Burst the Bottle Easily

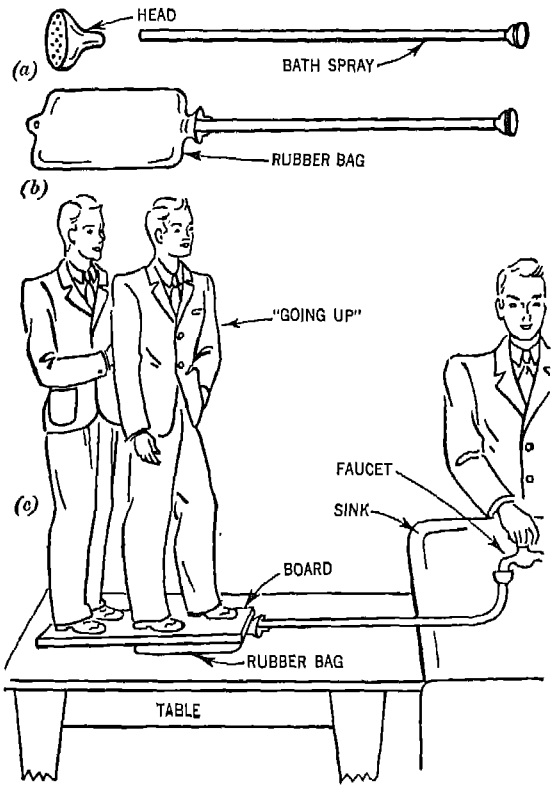
a. Find a board long enough to rest on the top of a large pail, and cut a notch in it just large enough to hold the rim of a bottle with *flat* sides.

b. Fit the neck of the bottle into the notch and fill the bottle with water until it overflows.

c. Insert the cork and make certain there is no air under it.

d. Hit the cork with a hammer, first gently and then harder and harder. You will be surprised how easily you burst the bottle.

Empty all the broken glass into the ash can.



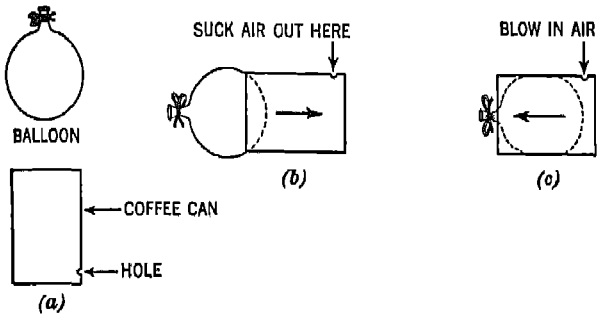
75. Water Lift

a. Remove the spray head of a bath spray.

b. Fasten the end of the rubber tube to the screw outlet piece of the rubber bag of a fountain syringe.

c. Place a board on the rubber bag on a table, have two friends stand on the board, connect the rubber tube to a faucet and turn on the water *gently*. You will see the water lift your friends.

WARNING: Do not fill the bag too full, or the water pressure will burst it.



76. Balloon and Coffee Can

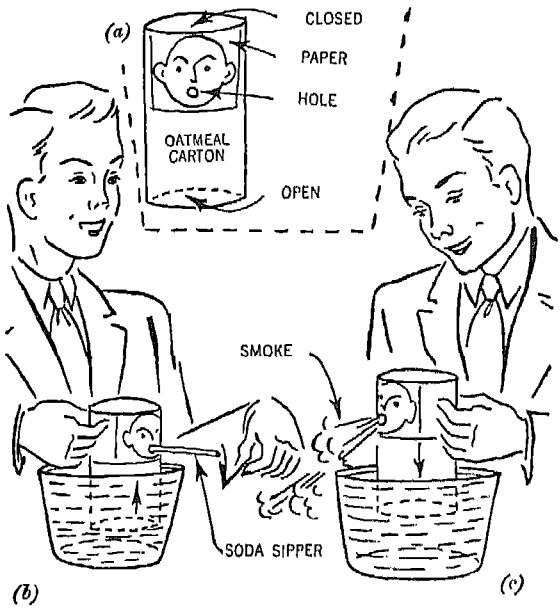
a. Blow up a round balloon until it is just a little larger than the mouth of a coffee can, and punch a nail hole near the bottom of the can.

Rub the outside of the balloon with a piece of wet soap to make it slippery.

b. Press the balloon against the mouth of the can and suck air out of the can through the hole.

The balloon slides into the can.

c. Blow air into the can and the balloon slides out again.

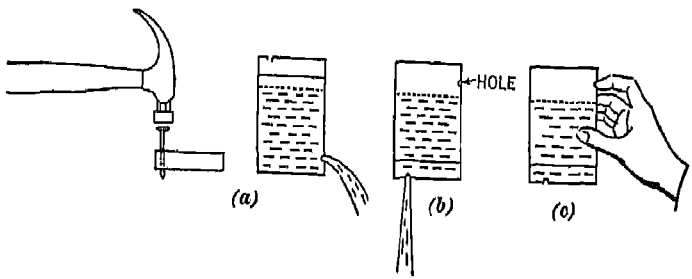


77. The Carton Smokes

a. Find an empty cardboard carton; paste a piece of white paper, 2½″ × 2½″, on its side near the closed end; mark a man's eyes, nose and ears on the paper; and, for the mouth, punch a nail hole just large enough to hold a paper soda sipper air-tight.

b. Put half of a paper soda sipper in the mouth. Sink the open end of the carton in water *up to the man's chin.* Hold a lighted match at the end of the sipper and raise the carton *slowly*, but keep its lower end under water. You will see the man draw in smoke.

c. Remove the sipper and sink the carton *slowly.* You will see the man puff out much smoke.



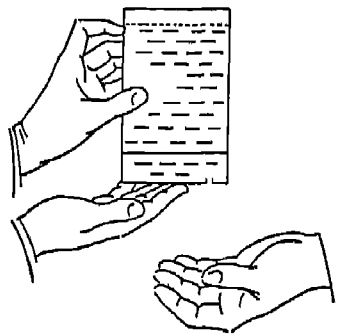
78. Stop and Go

a. Punch a nail hole in the cover of a coffee can and another hole near the bottom of the can. Put the cover on the can full of water.

b. Turn the can upside down and water will run out of the hole in the cover.

c. Put your finger over the hole in the side of the can and the flow will stop.

Remove your finger and the flow will start again.



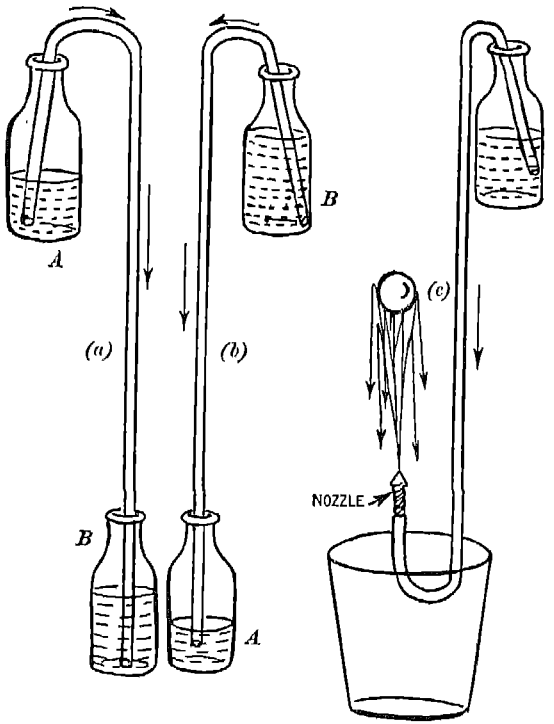
79. A Trick

Fill the coffee can with water, put on the cover, turn the can upside down and hold a finger or thumb over the hole in the side to stop the flow.

Now choose a friend who does not know about the holes, ask him to hold the can a minute, and give it to him in such a way that the hole in the cover is over his hand.

Remove your finger from the hole and walk away.

Your friend will be surprised to find his hand getting wet.

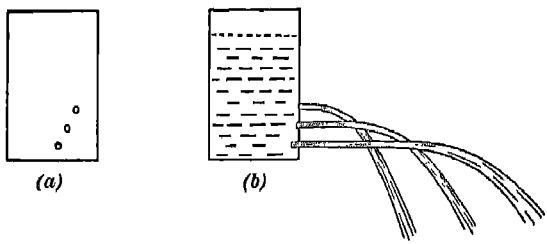


80. The Siphon Flow Reverses

a. Put one end of a rubber tube from a bath spray in bottle A full of water. Suck air out of the other end and put it quickly into bottle B. You will see the siphon run water from A to B.

b. Before A is empty, lower A and raise B, *being certain to keep both ends of the siphon under water.* The water flows now from B to A.

c. Arrange the bottle and rubber tube as shown, fit a nozzle into the lower end of the tube, or pinch it to make a narrow vertical stream, and place a ping-pong ball in the stream. You will see the ball bounce up and down in the stream.

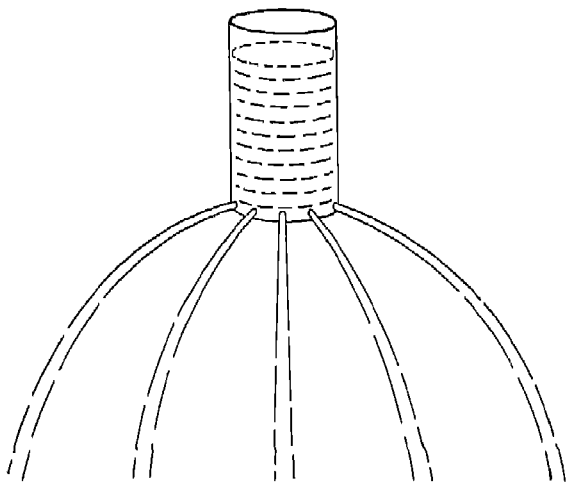


81. Three Holes in the Can

a. Punch three holes in the side of a tall can, for example, a can from grapefruit juice. The first hole should be near the bottom of the can; the second should be 1 inch above the first hole and a little to one side; and the third should be 1 inch above the second hole and a little more to the same side.

b. Fill the can with water, hold it high above a sink and you will see three fine jets.

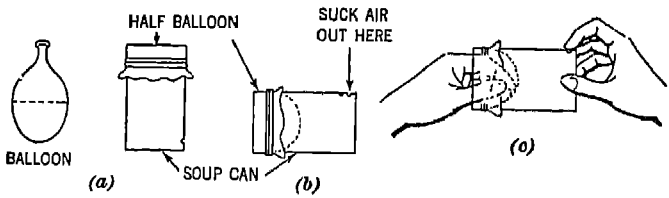
The longest jet is at the bottom and the shortest at the top.



82. Many Equal Jets

Take another tall can and punch five or six holes in the side about ⅛ inch from the bottom and ½ inch apart.

Fill the can with water, hold it high above a sink and you will see streams of equal length.



83. Soup Can

a. Find a round can of about the size used for canned soups. Cut a large round five cent balloon in two and fasten the bottom half over the open end of the can by means of a doubled rubber band.

NOTE: The open end of the can must be smooth around the edge to avoid cutting the rubber.

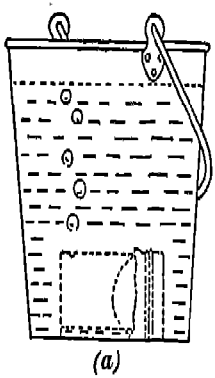
b. Punch a nail hole ⅛ inch from the bottom of the can. Suck air out of the can and the balloon rubber will move into the can.

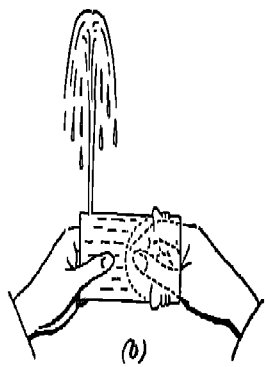
Let in air and the rubber will come out.

c. Press the rubber into the can and then put your finger over the hole in the side.

The rubber will stay in the can.

Let air into the can a little at a time and the rubber will come out a little each time.

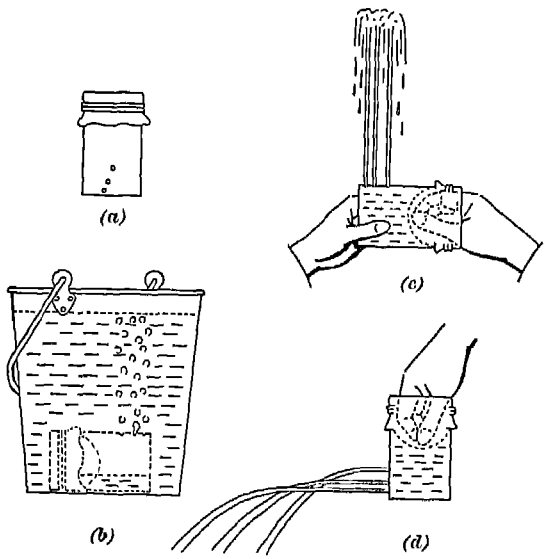




84. A Fountain

a. Hold the soup can horizontally under water and shove in the balloon rubber time after time until air bubbles stop coming out of the hole.

b. Lift the can out and shove in the rubber. You will get a fine fountain.



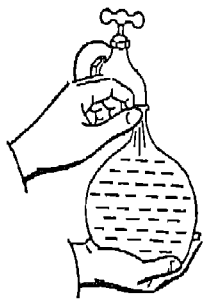
85. Triple Fountain

a. Punch two more holes in the soup can, ¾ inch and 1½ inches respectively above the first, and each ¼ inch to one side of the hole just below.

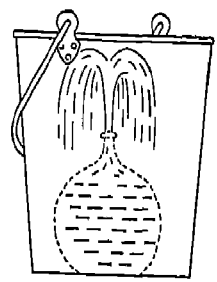
b. Hold the can horizontally in a pail of water and shove in the balloon rubber time after time until the air bubbles stop coming out of the holes.

c. Lift the can out, hold it with the holes on the top and shove in the rubber. You get three fine jets of *equal* height.

d. Hold the can high above a sink with the holes sidewise. Shove in the rubber and you get three jets of *unequal* length.



(a)



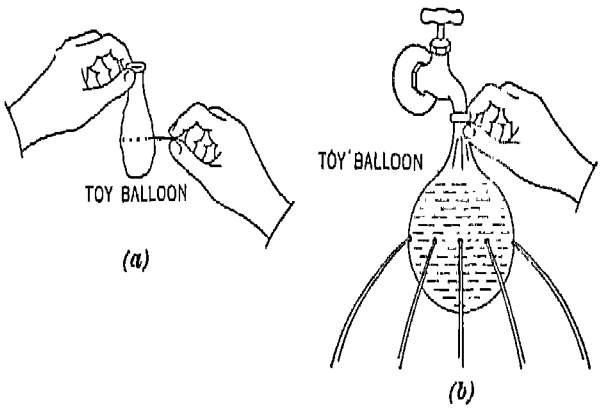
(b)

86. A Gusher

a. Fill a balloon with water while you support its weight below.

b. Pinch the neck, remove the balloon from the faucet, stand it in a pail or sink and release the neck.

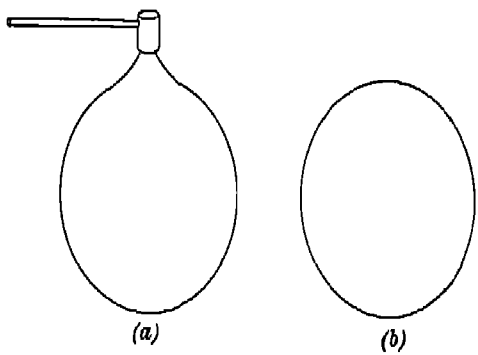
You will see a fine gusher.



87. Equal Water Jets

a. Punch pin holes through the side of a toy balloon at its equator.

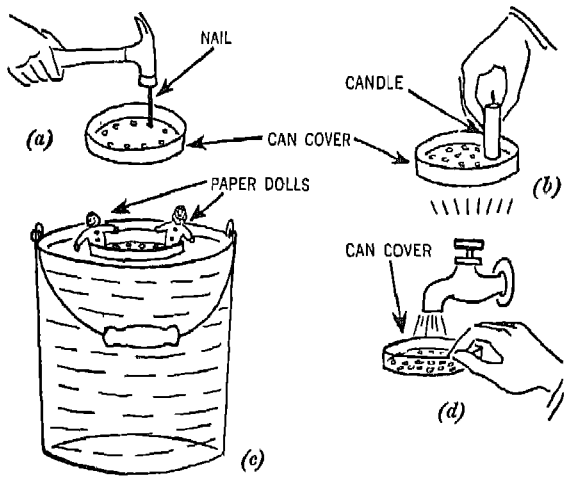
b. Fill the balloon with water and you will see that all the water jets are of equal length.



88. Air Pressure Equal in All Directions

a. Blow a soap bubble.

b. Detach it and notice that it is always a sphere. This shows that the air in the bubble transmits pressure equally in all directions. It shows also that the surface tension of the soap film is equal in all directions. See also Experience 121.



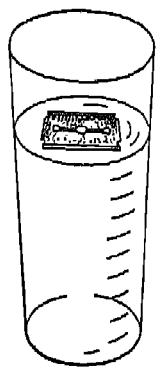
89. It Floats and Holds Water

a. Find the cover of a metal can and punch it full of nail holes.

b. Heat the cover enough to melt candle wax, rub it with a candle, and shake the candle wax out of the nail holes.

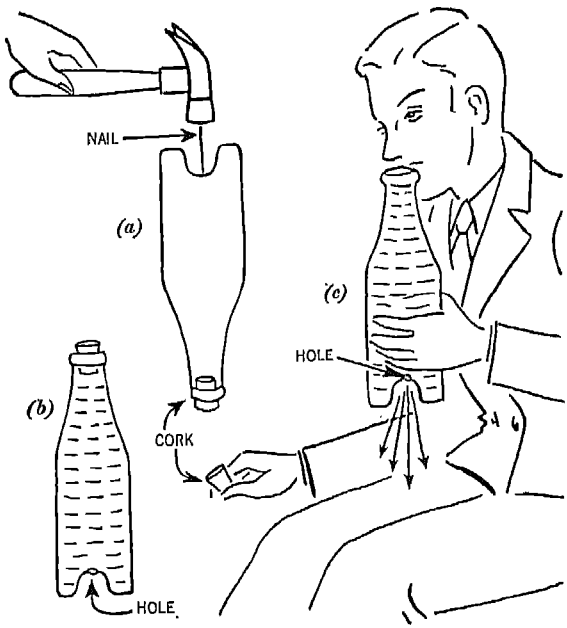
c. Cut out two paper dolls about one inch high. Seat them in the cover and place the cover on water. You will see that it floats although it is full of holes.

d. Remove the dolls and pour water into the cover. You will see that it holds water although it is full of holes.



90. Razor Blade

Drop a dry safety razor blade flat on the surface of water from a height of about 1/8 inch. It will float on the surface although steel is about eight times as heavy as water volume for volume.

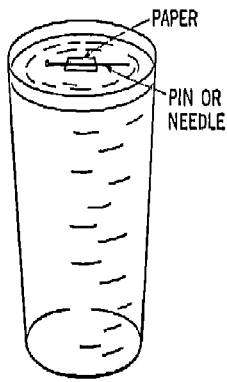


91. A Trick

a. Find a bottle with a "curved-in" bottom, cork it and use a hammer and a thin nail to punch a small secret hole through the bottom. Carry the bottle to the trash can, uncork it and shake the broken glass into the can.

b. Hold a finger over the hole, fill the bottle with water and add a few drops of perfume. Cork the bottle and you will see that it does not leak when you uncover the hole.

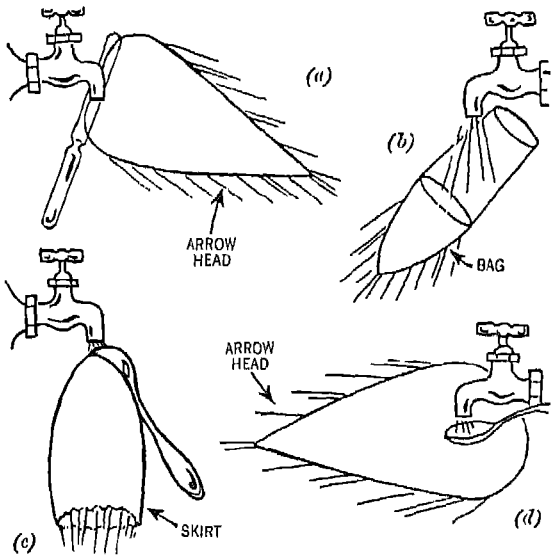
c. Seat a friend, and then hand him the bottle and ask him to tell you what perfume you used. After he has removed the cork and smelled a while, he will be *much surprised* to find that *he is getting wet.*



92. Pin and Paper

Float a small piece of paper on water and drop a dry pin or needle on the paper.

Sink the paper carefully and the pin or needle will float on the surface of the water.



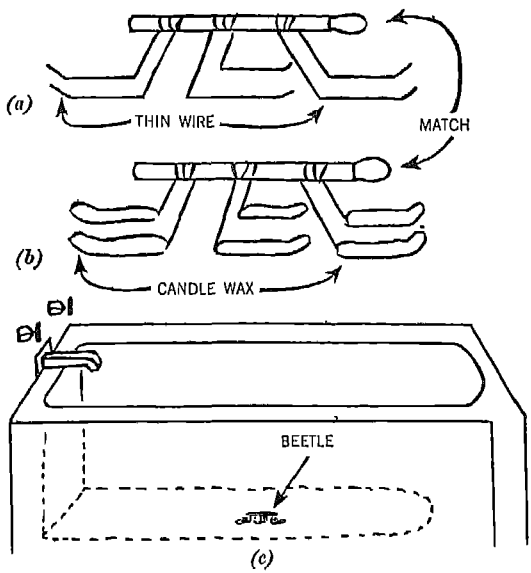
93. You Make Water Sheets

a. Hold the middle of the blade of a dinner knife in a horizontal position under a water faucet. Turn on the water more and more and direct the stream forward and slightly downward.
The water will spread into a thin sheet in the shape of a large arrow-head.

b. Use a small tumbler as shown, and the thin sheet of water will form a closed bag.

c. Hold the bowl of an inverted tablespoon as shown, and the thin sheet of water will form a skirt.

d. Use a teaspoon bowl, and the water will form another large thin arrow-head.

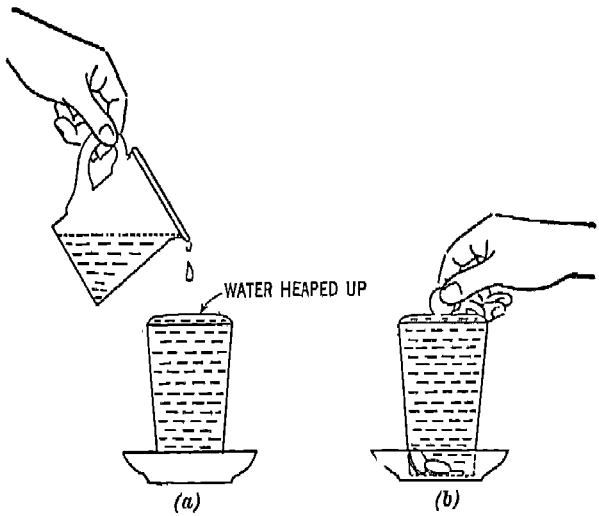


94. You Make a Water Beetle

a. Get a very thin wire similar to that used on some milk-bottle caps, and cut three 7-inch lengths. Use them to make six legs on a wooden kitchen match. Make each foot 1¼ inches long and turn up each toe ¼ inch. Make the six feet lie flat on the table.

b. Melt candle wax in a spoon and, as it cools, dip each foot in it, time after time, until it is thoroughly covered. You will then have a fine water beetle.

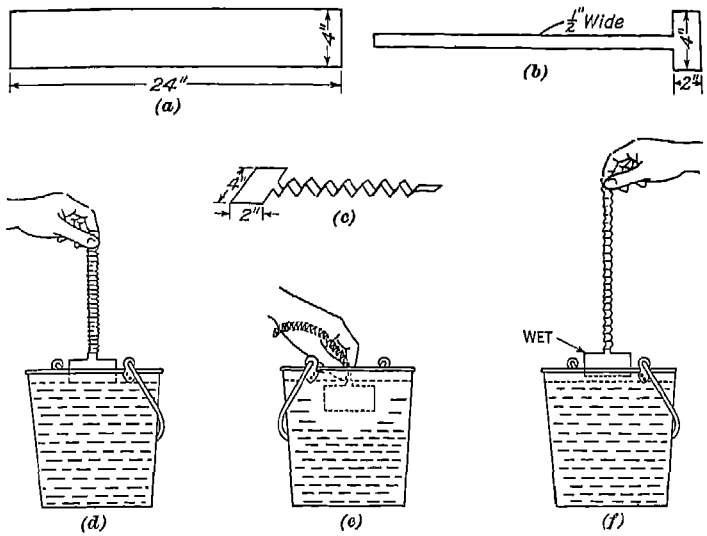
c. Run water into a bath tub or other large vessel until it is about one inch deep, and wait until the surface is still. Float the water beetle on the surface carefully, and then blow on it. You will see it skim gracefully over the surface.



95. Heap Up Water

a. Place a tumbler in a saucer and fill it with water. Notice that you can heap the water up an eighth inch or more above the top of the tumbler.

b. Fill a tumbler *level* full and drop in coins edgewise. You will be surprised to see how many you can drop in without making the water overflow.



96. The Water Surface Is Strong and Contractile

a. Cut a strip of light wrapping paper 4″ × 24″.

b. Cut it down to the shape shown.

c. Fold the long part back and forth into zigzags each 1 inch long.

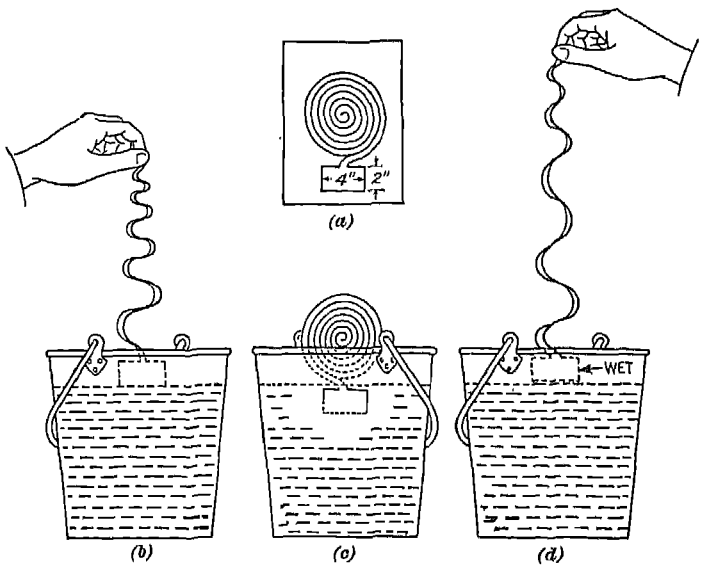
d. Hold the zigzag as shown and try to make the lower end pierce the water surface. You will see that the water surface is strong.

e. Wet the 4″ × 2″ part.

f. Hold the zigzag as shown and *very slowly* bring the wet 4″ × 2″ part into contact with the water surface. The water surface will grab the wet part and *jerk it down.*

Raise the zigzag *very slowly.*

The water surface will hold the wet part for a time and *stretch the zigzag.*



97. The Water Surface Is Strong and Contractile

a. On a piece of light wrapping paper mark a rectangle 4″×2″ and then draw a spiral ½ inch wide above it.

Cut out the rectangle and the spiral.

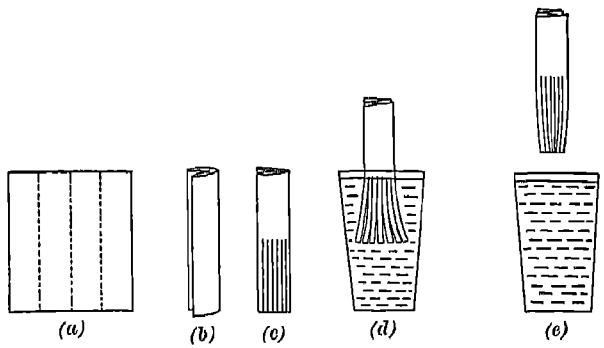
b. Hold the spiral at the top and try to make the rectangle pierce the water surface. You will see that the water surface is strong.

c. Wet the rectangle.

d. Hold the spiral at the top and *very slowly* bring the wet rectangle into contact with the water surface. The water surface will *jerk the rectangle downward.*

Raise the spiral *very slowly.*

The water surface will hold the wet rectangle for a time and *stretch the spiral.*



98. In and Out of Water

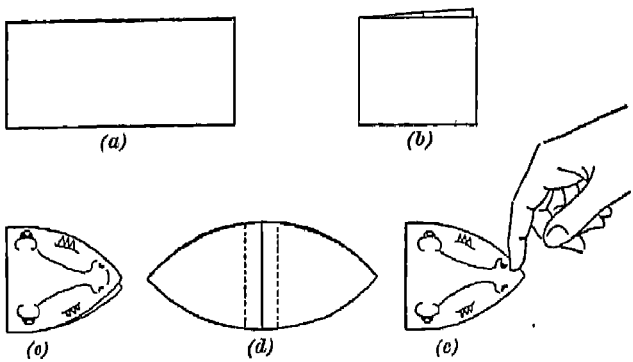
a. Cut a piece of newspaper about 4″×4″.

b. Fold it over twice.

c. Cut one half of it lengthwise into strips to make a brush.

d. Insert the brush into water and the strips will remain separated.

e. Lift the brush out of water and the strips will cling together.



99. The Alligator Opens Its Mouth

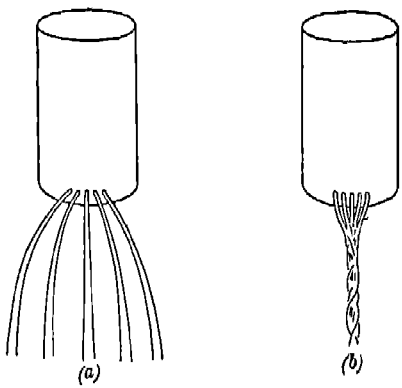
a. Cut a piece of smooth writing paper or wrapping paper about 5″x2″.

b. Fold it.

c. Cut it into the shape of an alligator head and draw its eyes and nose.

d. Wet the *crease* on the *inside only*.

e. Close the jaws by pressing down on the *end of the nose*. When you remove your finger the alligator will open its mouth.

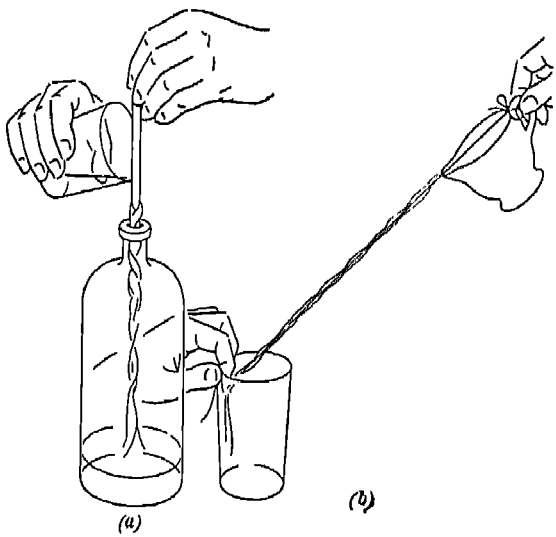


100. The Jets Cling Together

a. Punch five holes ¼ inch apart in the side of a tall can near the bottom. Fill the can with water and you will see five equal jets.

b. Pinch the jets together with thumb and finger and they will cling together.

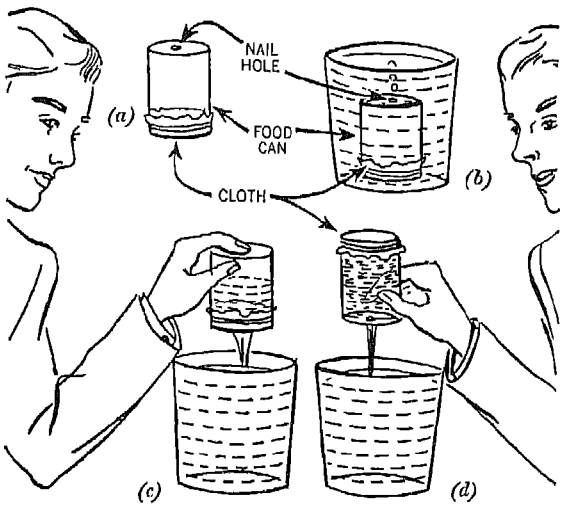
Slap the jets down close to the can and they will separate.



101. Aqueducts

a. Wash a pencil thoroughly with soap and water to remove the grease, then fill a tumbler half full of water and empty it into a narrow neck bottle with the aid of the pencil. The water will cling to the pencil.

b. Tie a *wet* string to the handle of a cream pitcher full of water, lay it in the notch of the spout and pour the water along it into a tumbler below and at one side. The water will cling to the string.



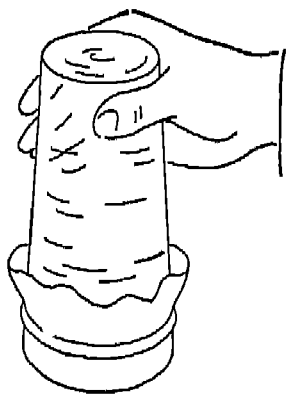
102. Stop and Go

a. Punch a nail hole in the bottom of an empty food can, and cover its open end with one thickness of cloth held on by a stretched rubber band.

b. Sink the can under water, with its cloth covered end below, and you will see air bubble up out of the hole.

c. Lift the can and you will see water run out through the cloth; but, when you close the hole, you will see the outflow stop *slowly*.

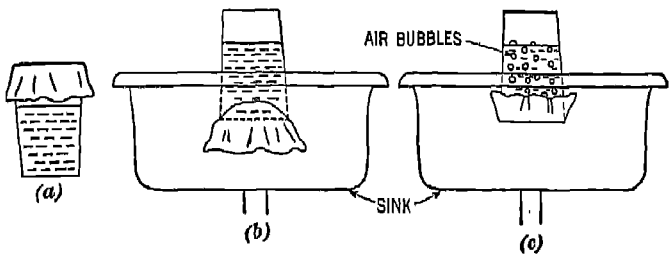
d. Fill the can with water, as in *b*. Invert it, and water will flow out of the hole; but it will stop *promptly* as soon as the cloth has curved down as far as it can go.



103. Cloth Holds Water

a. Wet a piece of handkerchief thoroughly and fasten it by means of an elastic band over a tumbler full of water.

b. Go to a sink and invert the tumbler *quickly*. The cloth will hold the water in the tumbler.



104. The Water Appears to Boil

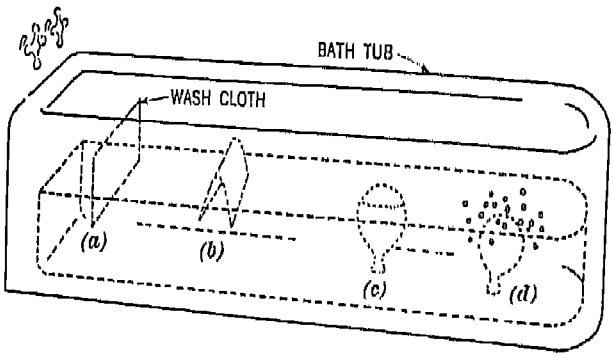
a. Wet a piece of handkerchief or other cloth and place it over a tumbler ⅔ full of water.

b. Hold the handkerchief on with the palm of your hand, invert the tumbler over a sink and remove your hand.

The handkerchief will be bent up into the tumbler and will hold the water without other support.

c. Hold the cloth all around except at one corner and pull up on this corner slowly to remove the bend.

Air will bubble up into the tumbler and make the water seem to boil.



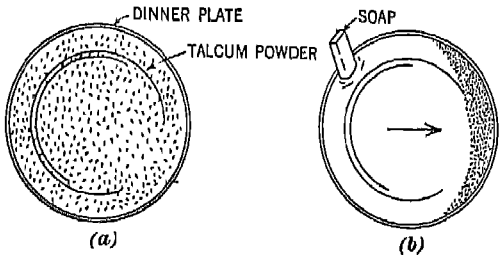
105. To Catch Air in a Wash Cloth

a. When you take your bath tonight, wet the wash cloth thoroughly and hold it with one edge under water.

b. Bend the upper edge down quickly.

c. Gather the cloth into a bag upside down.

d. Sink the bag under water and squeeze it.
Many air bubbles will appear in the water.



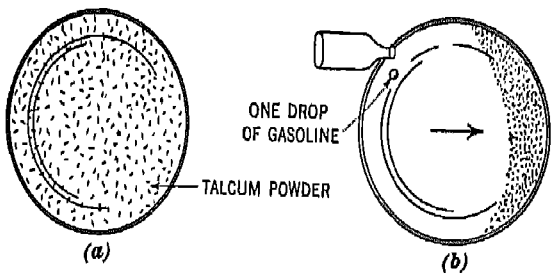
106. Water and Soap

a. Rinse a large clean dinner plate thoroughly, fill it with clean cold water, wait for the surface to become quiet and sprinkle the surface lightly with talcum powder.

b. Wet a piece of soap at the faucet and touch it to the water surface at one edge of the plate. The talcum powder will be drawn instantly to the opposite edge.

Remember, in the next half dozen experiences, always to rinse the plate very thoroughly in cold running water after each trial and to fill it with cold water without letting the water touch your fingers.

Use only the faintest trace of talcum powder.

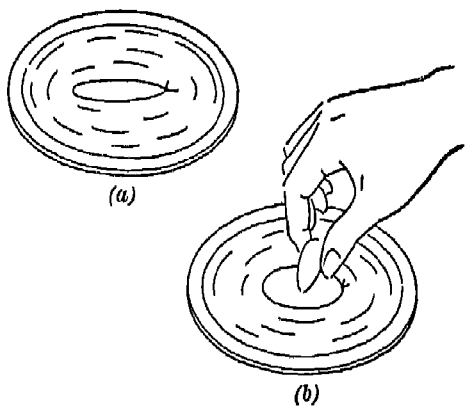


107. Water and Gasoline

a. *Rinse the dinner plate thoroughly*, fill it again with clean cold water, wait for the surface to become quiet and sprinkle it *lightly* with talcum powder.

b. Let one drop of gasoline fall on the water surface near one edge. The talcum powder will be drawn instantly to the opposite edge.

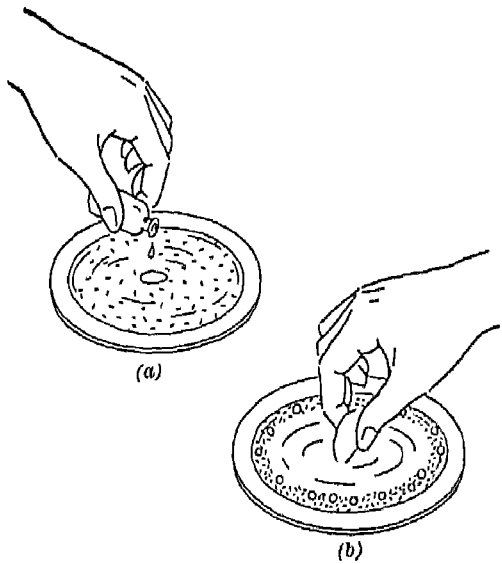
As the gasoline evaporates, the talcum powder will gradually move back over the water surface.



108. A Perfect Circle

a. Make a loop of light *silk* thread and float it on the *clean fresh* surface of a plate of water. Make sure that every part of the thread is on the surface.

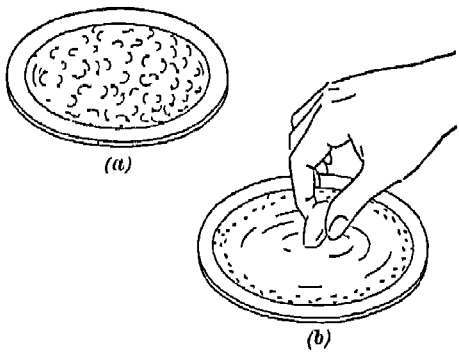
b. Touch a piece of wet soap to the surface inside the loop and the water surface outside the loop will draw the thread out instantly into a perfect circle.



109. Spheres

a. *Rinse the plate thoroughly* and fill it with fresh cold water, sprinkle the surface with a little talcum powder and let one or two dozen drops of kerosene fall on the surface at the center.

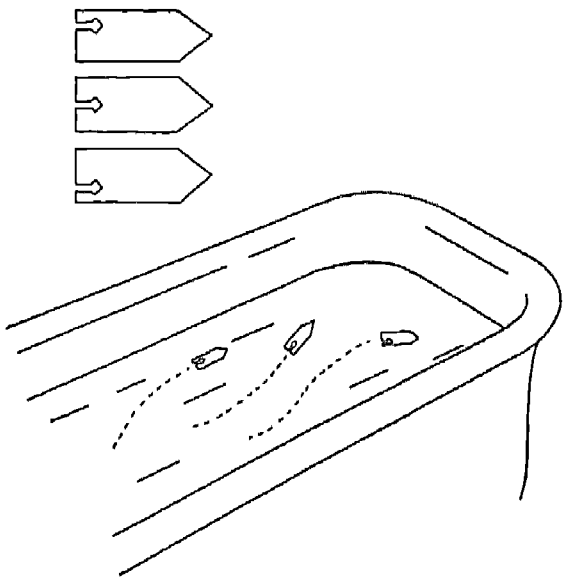
b. Touch the middle of the kerosene patch with a piece of wet soap. The kerosene will be instantly drawn to the edge of the plate where it will gather into small spherical drops.



110. Camphor

a. Buy a piece of camphor at the drug store. Cut off a piece about the size of a half pea. Place this on clean paper and cut it up very, very fine with a clean sharp knife. Drop the crumbs on a plate of *fresh clean* cold water and they will dash about in a lively manner. Do not handle the camphor because oil from your hands will spoil the effect.

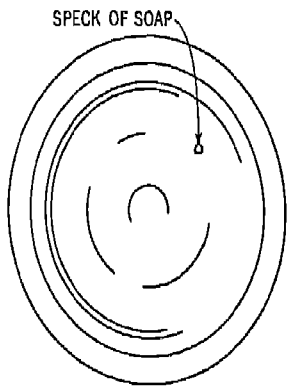
b. Touch a piece of wet soap to the center of the water surface and the camphor particles will be instantly drawn to the edge of the plate and will stop moving.



111. Boats

Cut two or three small boats, about 1 inch long, out of writing paper, and cut a slot and pocket at the stern of each. Place a piece of camphor in each pocket in such a way that it touches the water, but does not fall out.

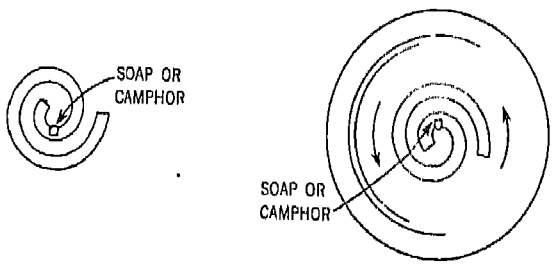
Float the boats in a pail, dish pan or bath tub and they will sail around for a long time.



112. A Speck of Soap

Fill a dinner plate with *fresh* cold water and drop on it a speck of soap about a fourth the size of a pin-head—the smaller the better.

The speck will dash about in a lively manner for a minute or so.



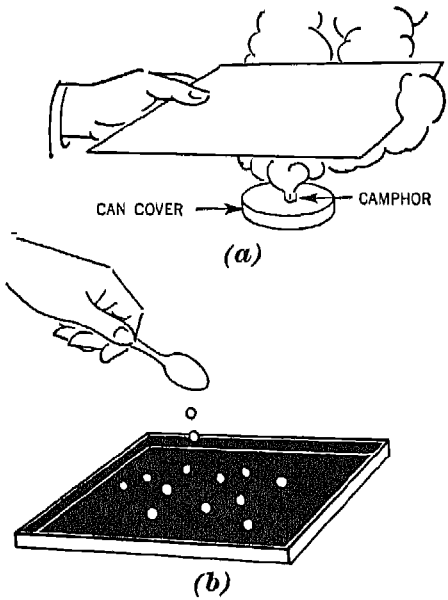
113. Spiral

a. Hold two pencils side by side and draw, on paper or light cardboard, a double spiral about ½″ wide. Cut out the spirals.

Fasten a small sliver of soap or camphor in a slit near the inner end in such a way that it will touch the water but will not fall out.

b. Fill a dinner plate with *fresh* cold water and float the spiral on it.

The spiral will turn rapidly for a short time with soap and slower but for a longer time with camphor.

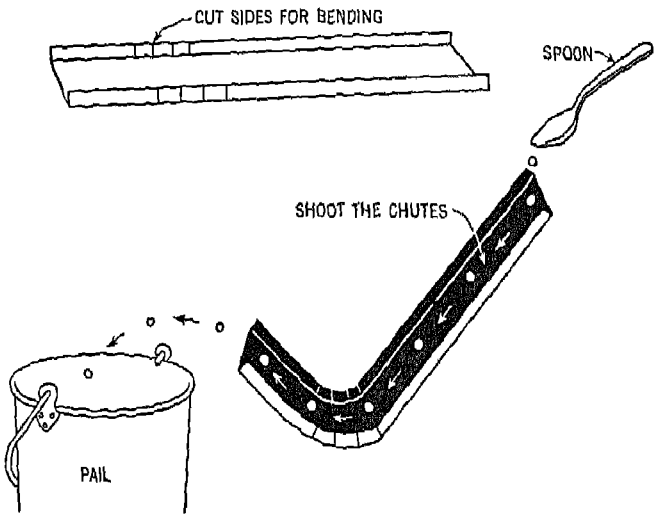


114. Drops

a. Place a small piece of camphor about ½"x½"x½" on the bottom of an inverted coffee can cover. Cut a piece of wrapping paper 15"x15".

Light the camphor and move one surface of the paper back and forth rapidly in the smoke of the camphor and as near the camphor as you can, without putting out the flame. Smoke the paper over and over until one surface is very black with soot. Turn up the edges of the paper slightly.

b. Let water from a small spoon fall on the smoked paper and it will form small spherical drops which will roll readily on the smoked paper.

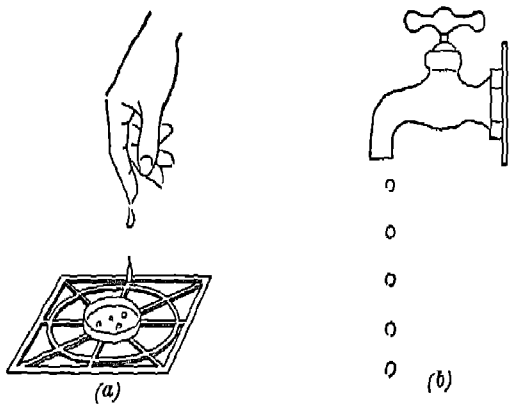


115. Shoot the Chute

a. Cut a piece of wrapping paper 6″ wide and 24″ long. Turn up the long sides 1 inch. And cut these turned-up sides for bending, as shown.

Smoke the inside of this paper thoroughly with camphor, as in the last experience.

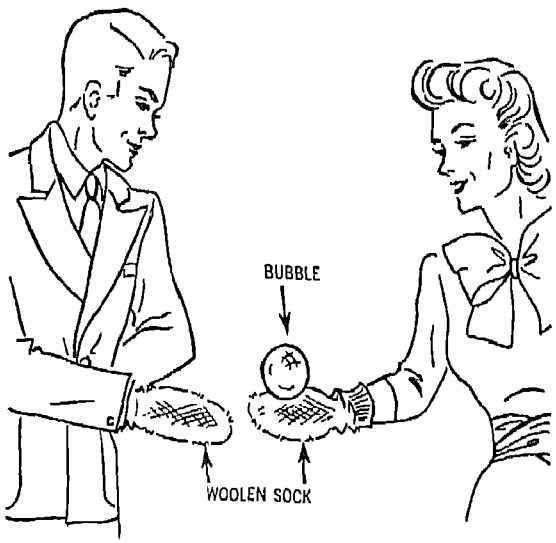
b. Arrange a chute, let water fall on its upper end and the drops formed will shoot the chute very rapidly.



116. Spheroidal State

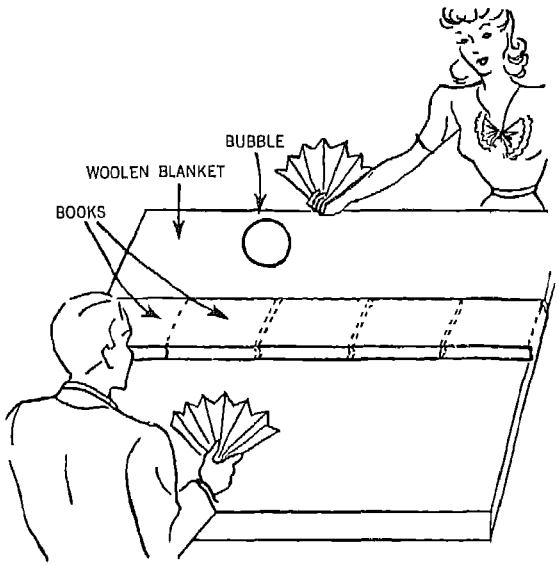
a. Place a coffee can cover over a lighted burner. Dip your fingers into water and shake drops of water into the hot cover. The water will remain as liquid spheres a considerable time.

b. Turn on a water faucet very slightly and notice how the water takes the form of spherical drops.



117. A Bubble Party

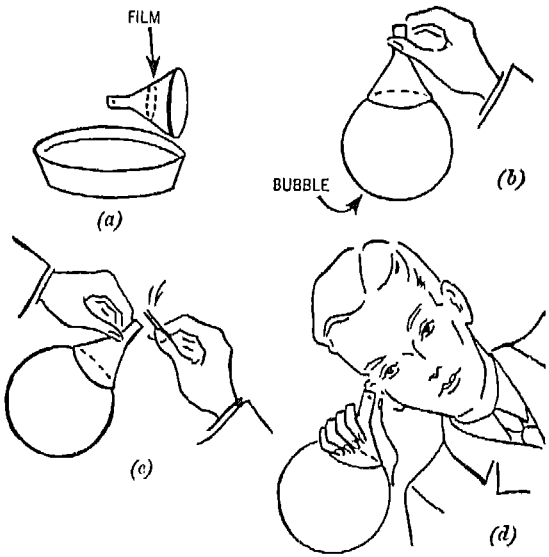
Cover the right hand of each partner with a dry *woolen* sock, mitten or glove. Blow a soap bubble and bat it gently back and forth. The winners are the partners with the highest score in three trials.



118. A Soap-Bubble Game

Place a row of books across the middle of a table, and cover the books and table top with a woolen blanket. Use real fans or make two out of paper that is folded properly.

Blow a soap bubble, drop it on the blanket in front of the lady, and let her try to fan it over the books. If she succeeds, the man tries to fan it back. Then the lady tries to fan it to the man's side again and so on. If the bubble bursts on the man's side, count ten points for the lady, and vice versa. Fifty points is game. The players take turns serving and do not interfere with one another.



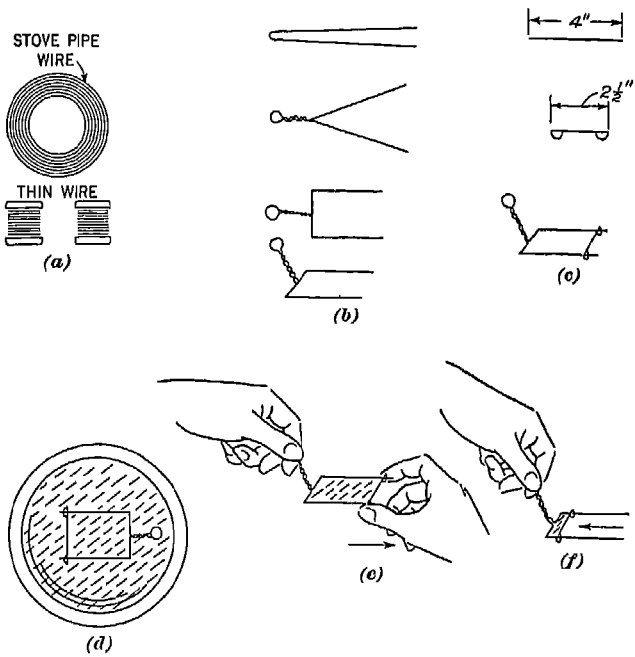
119. The Bubble Contracts

a. Wet the inside of a household funnel with soapy water; then get a soap film on its mouth and watch the film contract up into the funnel.

b. Blow a large bubble, and watch it contract.

c. Blow another bubble, and let it blow out a match held near the small end of the funnel.

d. Blow another bubble, and listen to the air stream it drives out of the small end of the funnel as it contracts.



120. Fork and Slider

a. Use iron stove-pipe wire, 50 feet for 5 cents, and buy a spool of very thin wire, 2 spools for 5 cents.

b. Cut a 12″ length of stove-pipe wire, double it, and twist the doubled end together for 2″ to make a handle. Make a two tined fork with tines 3″ long and 2″ apart. Bend up the handle and make the tines *parallel.*

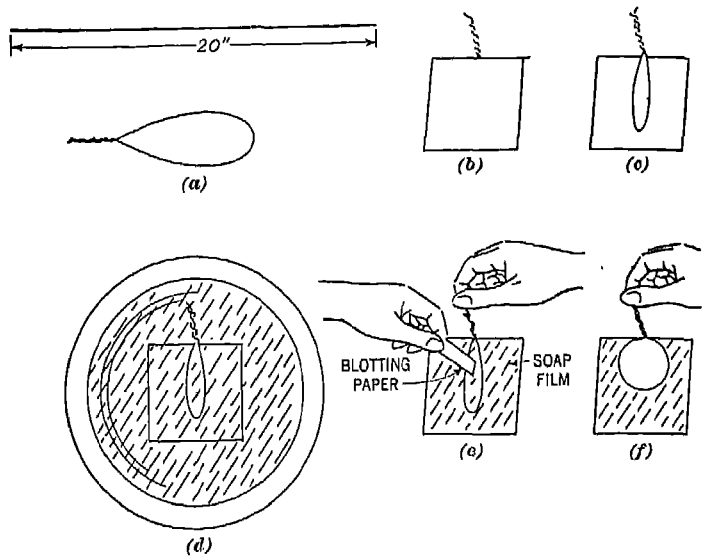
c. Cut a 4″ length of very thin wire and make a slider 2½″ long with a ¼″ loop at each end. Fit the slider over the tines and see that it moves the whole length easily.

d. Fill a dinner plate with thick soap solution and dip the tines and slider under the solution.

e. Lift the fork and get a soap film between the tines and slider. Pull out the slider and the soap film will stretch.

f. Release the slider and the soap film will contract and draw the slider up to the yoke of the fork.

Soap solution. Put three level tablespoonfuls of soap flakes or soap powder into a quart milk bottle, add 4 cups of hot water and let it stand for two or three days. You need a rather thick soap solution for this experience and the next.



121. Square and Loop

a. Cut a 20″ length of stove-pipe wire and twist the ends together for 2″, to make a handle.

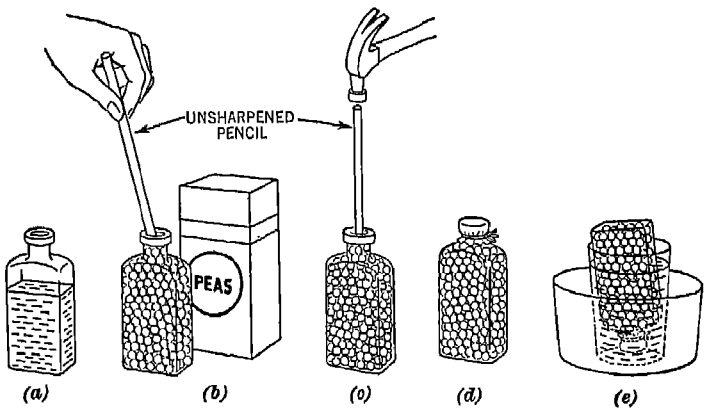
b. Make the remaining 16″ into a square, 4″ on each side, *with the handle at the middle of one side.* Bend up the handle.

c. Cut an 8″ length of *light silk* thread, tie it into a loop 3½″ long and hang it over the handle.

d. Pour thick soap solution into a dinner plate and dip the square and loop under the solution.

e. Lift out the square and loop, one side first, to get a soap film over the square. Touch the soap film inside the loop with a piece of blotting paper.

f. The soap film outside will pull the loop out instantly into a perfect circle.



122. The Peas or Beans Burst the Bottle

a. Find a four-ounce bottle *with flat sides* and fill it three-quarters full of water.

b. Fill the bottle with *dried* peas or beans, and ram down the last with an unsharpened pencil to make sure that the bottle is full to the top with tightly packed peas or beans in water.

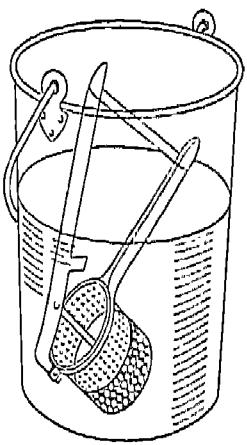
c. Put in two or three more peas or beans and tap them down gently with a hammer and the unsharpened pencil. Repeat this twice more, if you can.

d. Tie a cloth securely over the mouth of the bottle.

e. Stand the bottle *upside down* in a tumbler half full of water, and stand them both in a pan.

Inside of 48 hours the peas or beans will burst the bottle.

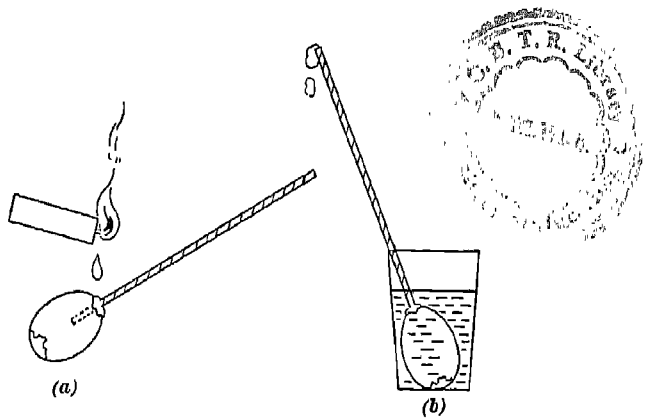
Why? See page 219.



123. The Peas or Beans Break the Cord

Fill a potato ricer one-third full of dried peas or beans. Tie the handles together with a piece of strong cord and put the ricer into a pail of water.

Inside of 48 hours the peas or beans will break the cord.



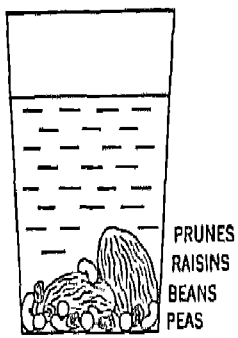
124. The Contents of the Egg Move Uphill

a. At one end of a fresh egg, punch a nail hole large enough to admit a soda straw and pierce the inner membrane.

At the other end, remove the shell from an area of about ¾ square inch but do not break the inner membrane.

Now insert the soda straw about 1 inch into the egg and drop hot candle wax on the joint to make it water tight.

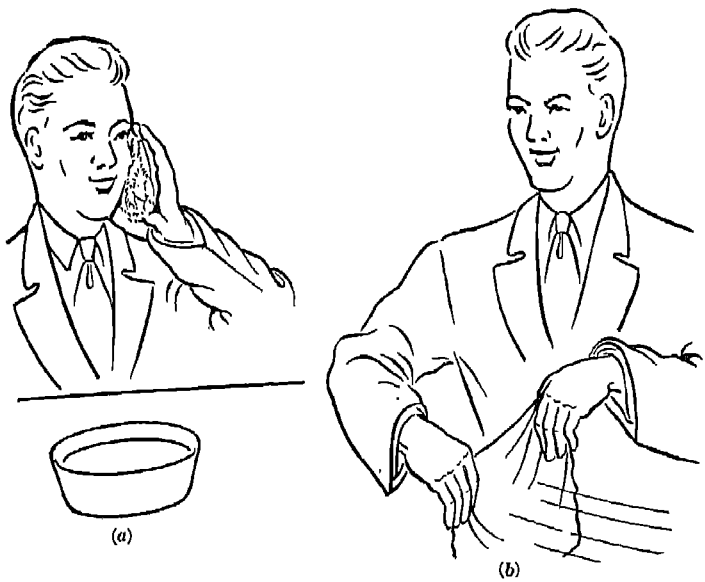
b. Stand the egg in a tumbler of fresh water and in an hour or two you will see the contents of the egg oozing from the top of the straw.



125. Dried Fruits and Seeds Swell in Water

Put 2 dried prunes, 5 raisins, 5 beans and 5 peas into a tumbler of water and observe their condition each day for three days. The fruits and seeds will swell.

This is what happens when seeds are planted in moist ground.



126. Cooling by Evaporation

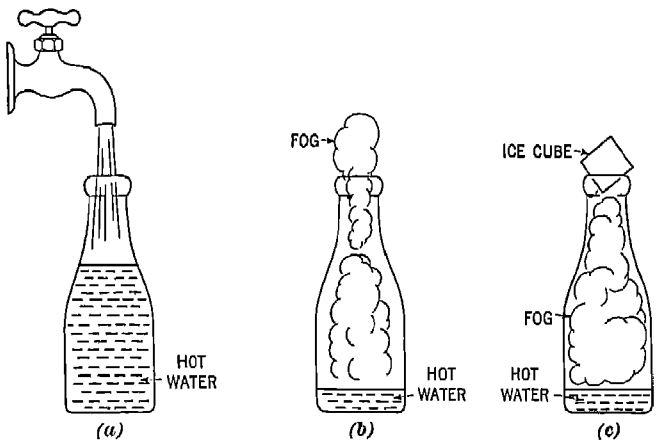
a. Wet a wash cloth in warm water, wring it out, and hold it against your cheek; and notice its warmth.

b. Wave the wash cloth back and forth thirty times through a distance of 3 or 4 feet. Then hold it against your cheek again, and notice how much it has cooled by the evaporation of part of the water on it.

127. Cooling by Evaporation

Blow on the back of your hand and it will feel cool.

Moisten the back of your hand and blow on it. It will feel cooler.



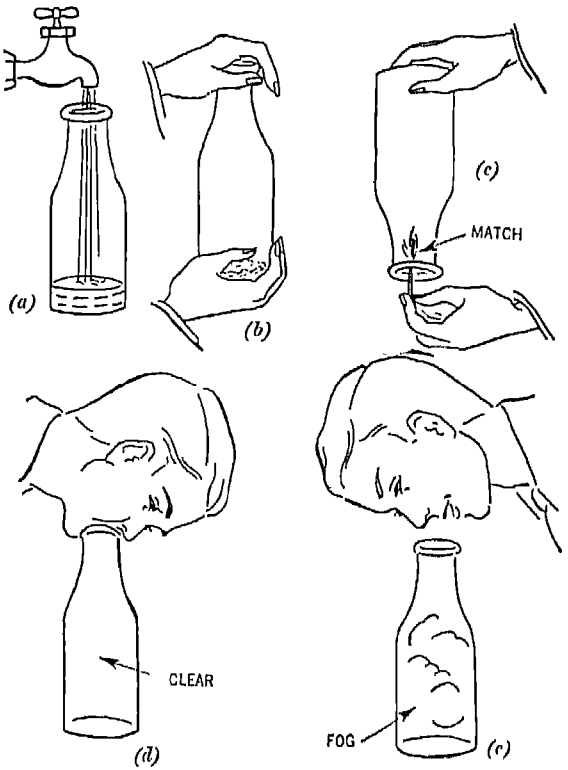
128. Fog

a. Fill a milk bottle with hot water and empty it except for one inch in the bottom.

b. Hold it up to the light and you will see thin streams of fog rising from the bottle.

c. Put an ice cube in the mouth of the bottle, hold the bottle up to the light and you will see thin streams of fog moving down into the bottle.

Fog is formed in nature when warm moist air is cooled by cold air or otherwise.



129. You Make Fog

a. Pour an inch depth of cold water into a quart milk bottle.

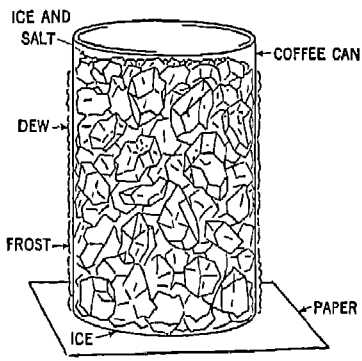
b. Hold your hand over the mouth and shake the bottle thoroughly to saturate the air in it with water vapor. Spill out the water.

c. Light a match, blow it out, and quickly hold the smoking match head in the mouth of the inverted bottle. The tiny smoke particles help the water vapor to condense to water drops.

d. Place the bottle in a *good light*, press your mouth down air-tight on its mouth and puff hard. You will see clear air in the bottle.

e. Lift your head and you will see fog form in the bottle.

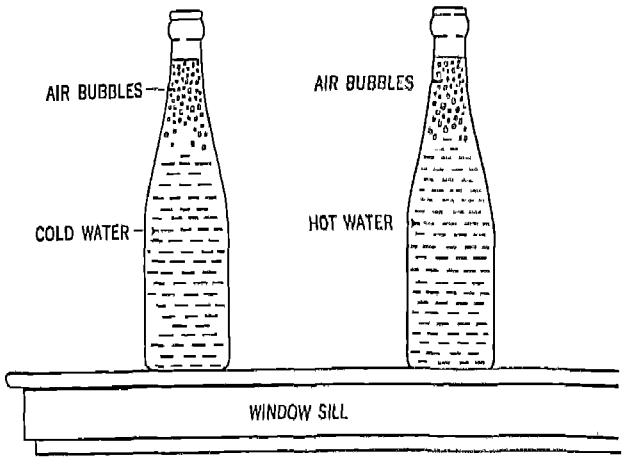
You can repeat *d* and *e* many times.



130. Dew, Frost and Freezing

Put cracked ice in a coffee can and stir it with about one-third its volume of salt. Pour a half teaspoon of water on a piece of paper and stand the can on the wet paper.

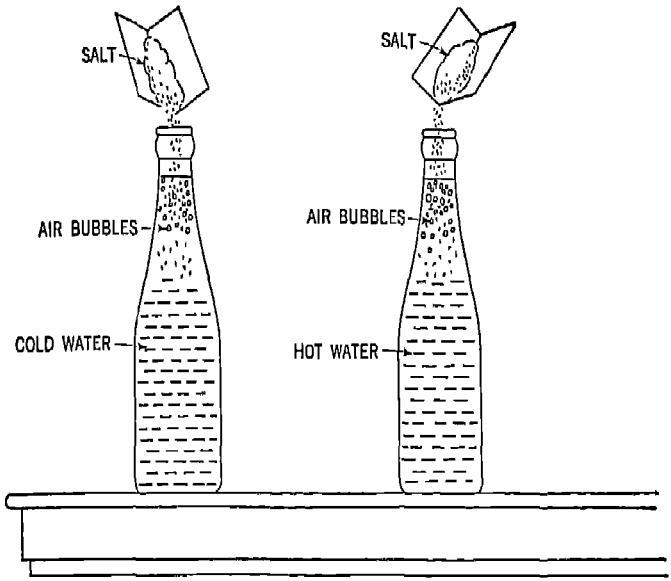
You will see dew and frost form on the side of the can and the paper frozen to the bottom of the can.



131. Air in Water

Fill one quart soda bottle from the cold water faucet and another from the hot water faucet. Stand them on a window sill.

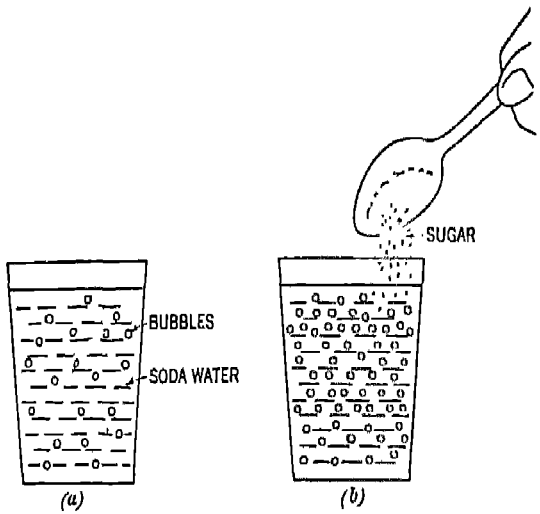
Look at the water near the top and you will see millions of tiny air bubbles rising in the water.



132. Salt Drives Out Air

When the air bubbles have stopped rising in the last experience, pour a heaping tablespoonful of table salt into each bottle. Cover and turn each upside down once to mix the salt and water.

You will see many more air bubbles rising in the water.



133. Sugar Drives Out Gas

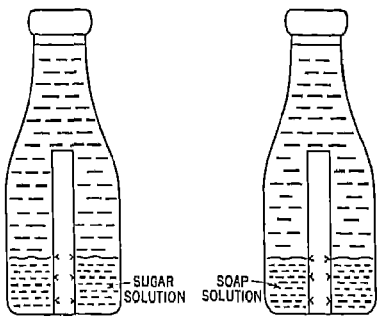
Soda water is carbon dioxide gas dissolved in water, with some flavoring matter.

a. Pour out a glass of soda water and look at it.

You will see many bubbles of carbon dioxide gas.

b. Pour a heaping teaspoonful of sugar into the soda water and stir it.

You will see the gas bubbles form very rapidly.

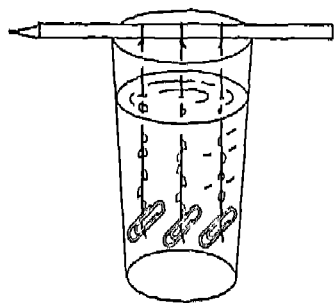


134. Diffusion

Paste a strip of paper up the side of each of two quart milk bottles. Fill the bottles with water. Drop into one four large lumps of sugar and into the other four lumps—about the size of the sugar lumps—of soap which sinks. Cap the bottles and stand them in a quiet place.

The sugar dissolves in the water and forms a heavy solution which diffuses upward very slowly. The soap acts in a similar manner.

Mark on the paper each week the height of each solution and the date.



135. Crystals

Buy five cents worth of alum, dissolve it in hot water and pour the solution into a tumbler.

Fasten a paper clip to the lower end of each of three strings and hang the strings in the solution from a pencil above the tumbler.

Observe the solution each day and you will see crystals of alum forming on the strings and at the bottom of the tumbler.

Try this also with table salt, Epsom salt and saltpeter.

Science Experiences

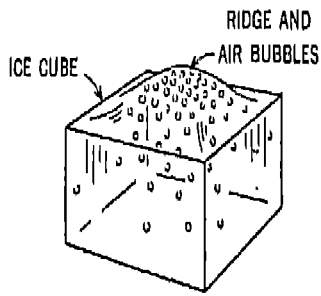
136. Invisible Ink

Make a concentrated solution of table salt in hot water and let it cool.

Write your name with this salt solution with a new clean pen which has never touched ink.

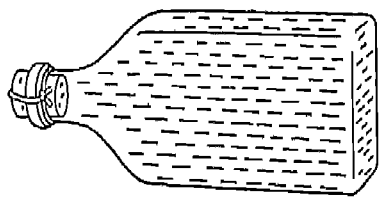
Let the writing dry and it will be almost invisible.

Rub across it with a lead pencil and your name will appear.



137. Water Expands on Freezing

Examine an ice cube. It is bulged at the center because the water expands on freezing. Note also that the air bubbles are most numerous at the bulge. The ice crystals in forming tend to drive out the air.



138. The Ice Bursts the Bottle

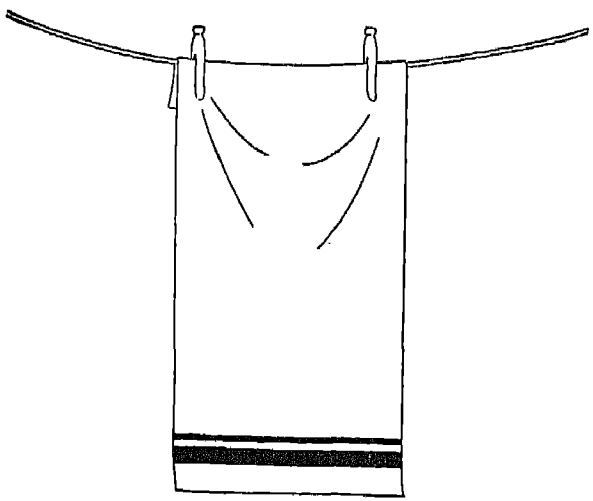
Find a four ounce bottle with *flat* sides.

Fill it with water and let it stand until the air bubbles escape.

Insert the cork firmly and *tie it in.*

Place the corked bottle over night in an empty ice cube tray in the ice cube space of a refrigerator.

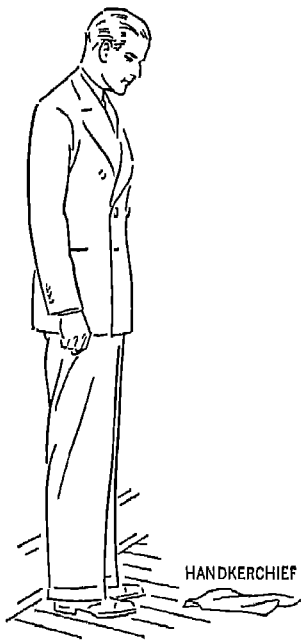
You will find the bottle broken in the morning.



139. Ice Evaporates

Wet a towel, wring it out and hang it outside to dry on a day *in winter* when the temperature is *below freezing.*

The water freezes to ice yet you will find the towel nearly free from ice next day.



140. Heels and Shoulders Against the Wall

Stand with your heels and shoulders against the wall.

Drop a handkerchief on the floor about a foot from your toes and try to pick it up without moving your feet or bending your knees.

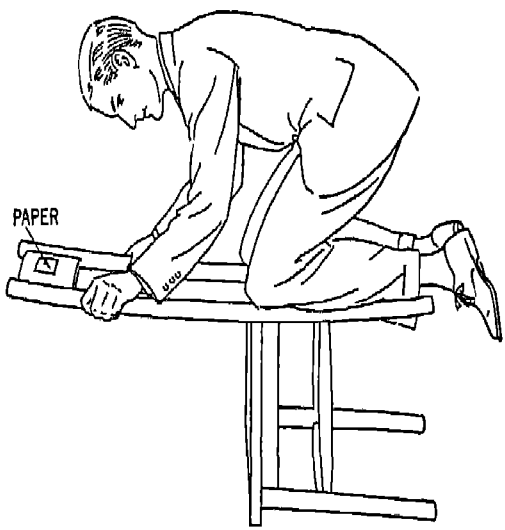
You will find you can not do it.

Why? See page 221.

141. Back Horizontal

Place a chair near the wall. Bend over it with your head against the wall and with your feet far enough away from the wall to make your legs, from heels to hips, slant toward the wall. Lift the chair from the floor and then try to straighten up without moving your feet.

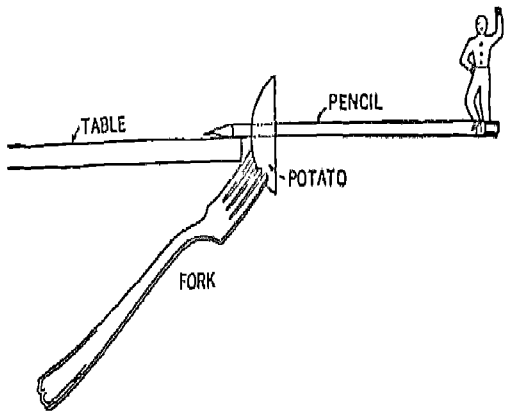
You will find you can not do it.



142. Chair Back

Use a stout chair as illustrated and try to pick up the paper with your lips.

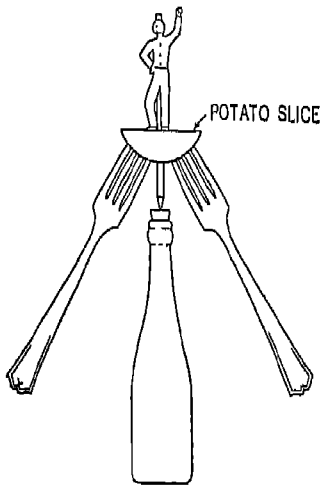
You will find it hard to do.



143. Potato, Pencil and Fork

Cut a slice of raw potato one inch thick. Drive the point of a pencil through it about one inch, attach a light cardboard man to the rubber end of the pencil. Insert the fork, and balance the device on the corner of a table.

Give the pencil a slight push downward and the man will bob up and down.

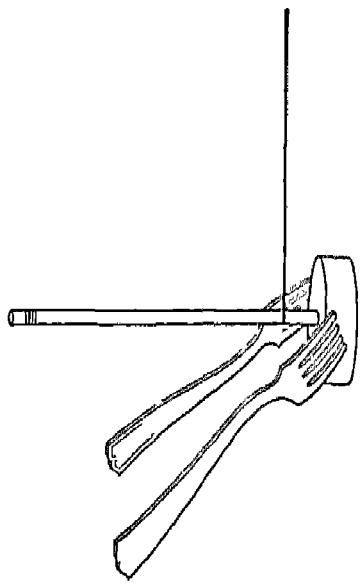


144. Potato, Pencil and Forks

Cut a slice of raw potato about one inch thick.

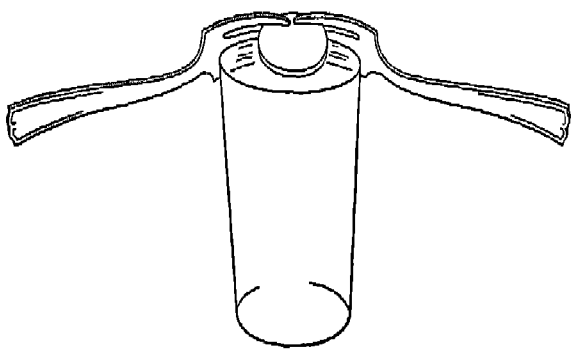
Drive a pointed pencil through it for a distance of about ½ inch. Cut a little man out of paper and fasten him to the upper part of the pencil. Insert two forks and balance the pencil point on a cork in a soda bottle.

Give the pencil a twirl and the device will spin merrily.



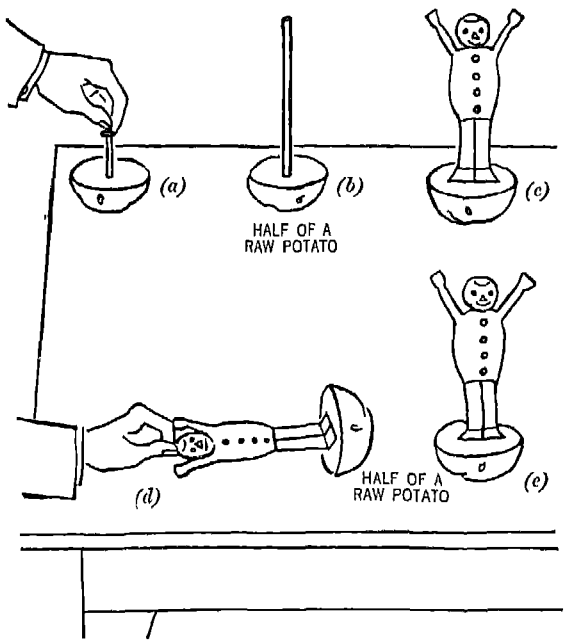
145. Potato, Pencil and Forks

Insert into a slice of potato the point of a pencil and the tines of two similar forks; then suspend them as illustrated. They will balance.



146. Forks and Fifty-Cent Piece

Insert a fifty-cent piece between the first and second tines of two similar forks and balance the group on the edge of a tumbler.



147. He Bobs Up Serenely

a. Cut a large *spherical* raw potato in half and, at the middle of one half, bore a hole just large enough to hold a paper soda sipper.

b. Insert a paper soda sipper.

c. Cut out a paper man and glue him to the soda sipper.

d. Tilt the little man.

e. Release him and he will bob up serenely.

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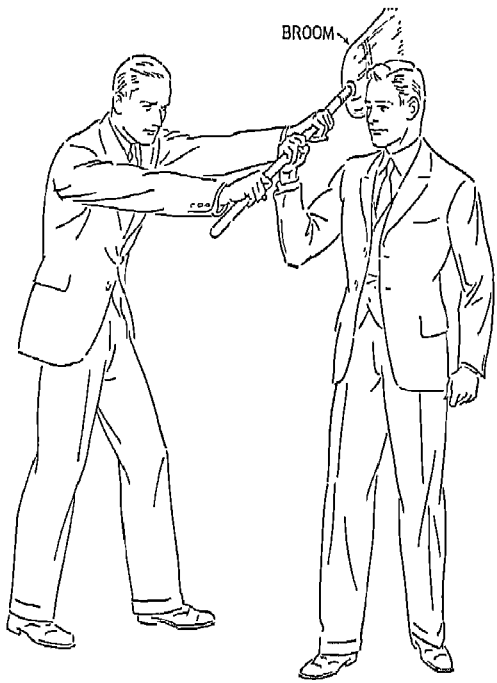
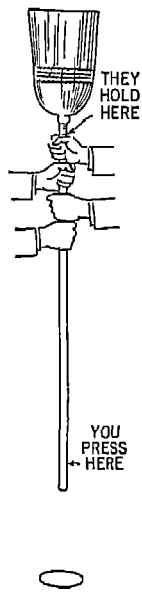
man and glue his hands to the [illegible] the horse on the corner of a table and give his head a gentle push downward. He will appear to gallop on air.



151. He Can't Shove You Over

Let a friend hold a broom handle horizontally at arms' length with both hands, while you stand opposite him with one hand under the handle.

Let him move forward about 1 foot to shove you over. He can not do so if you push up hard on the handle.

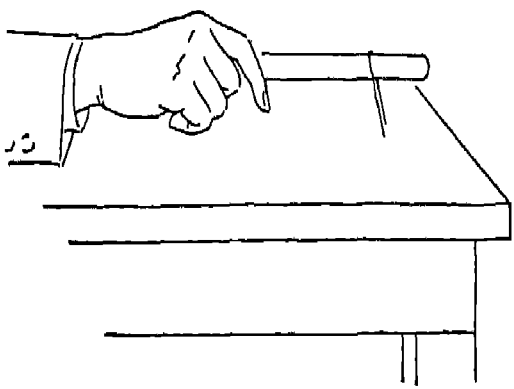


152. They Can't Hit the Circle

Draw a circle four inches in diameter on the floor. Let two friends hold a broom handle vertically at arms' length with their hands close together near the broom-straw end.

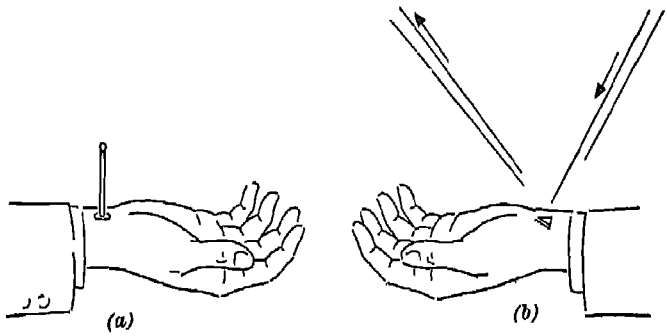
Let them hold the end of the handle one foot above the circle and try to move it downward to hit the circle.

They cannot do so if you sit on the floor and move the end sidewise with a little finger.



153. Knife and Hair Pin

Hold a table knife in a horizontal position, place a hair pin on the blade and, without resting your hand or arm on the table, lower the knife horizontally until the ends of the hair pin rest on the table. The hair pin will slide along the blade. Try two hair pins.

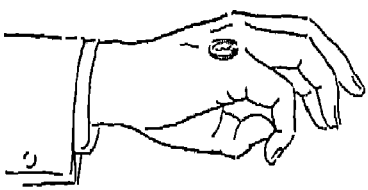


154. Your Pulse

a. Stick a match on the point of a thumbtack. Stand the head of the tack on your pulse and the head of the match will bow solemnly each time your pulse beats.

b. Use a pair of pliers to break a triangle about ¼″×¼″×½″ from the corner of a five-cent mirror. Place this mirror on your pulse and hold your arm in strong sunlight.

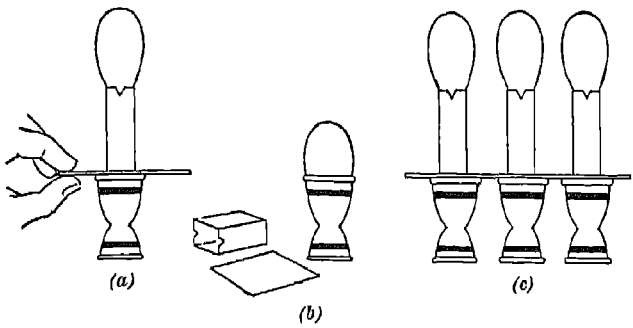
The spot of sunlight reflected to the wall or ceiling will move 6″, more or less, each time your pulse beats.



155. A Trick

Place a cent or dime on the back of your hand just over the upper knuckle of your little finger. Place the end of the little finger *under* the thumb. Flick the thumb away from the little finger and you will turn the coin over, with a little practice.

Ask your friends to try this. Most of them will fail because they will put the little finger *above* the thumb.



156. Egg and Egg Cup

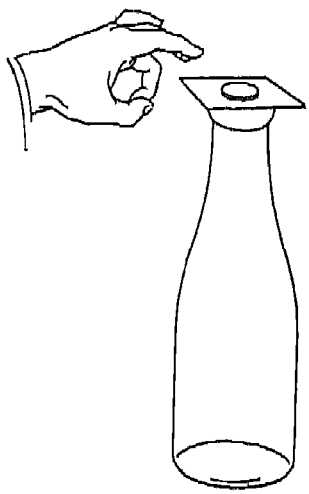
a. Balance a hard-boiled egg on a match box on a piece of cardboard on an egg cup. Use only the outer part of the match box and cut notches to hold the egg upright. Be sure that the center of the egg is exactly over the center of the cup.

b. Jerk the cardboard out horizontally and the egg will drop into the cup.

c. Similarly use three eggs on three match boxes on a single piece of cardboard on three egg cups.

Jerk the cardboard out sidewise and each egg will drop into a cup.

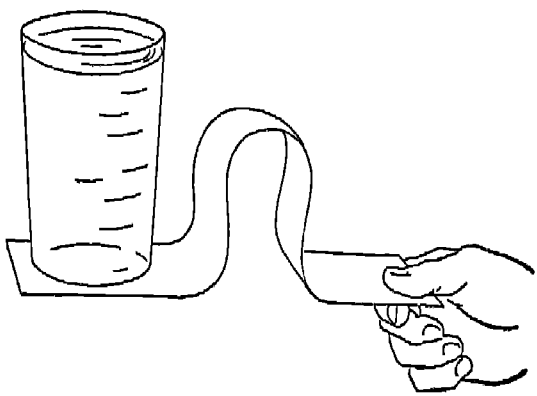
Why? See page 222.



157. Coin, Card and Bottle

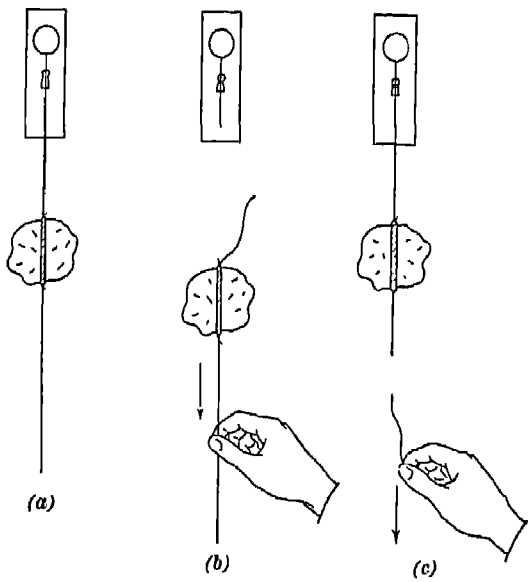
Place a coin on a card over the mouth of a milk bottle. Flick the card horizontally and it will fly out.

The coin will not move horizontally but will simply drop into the bottle.



158. Tumbler and Paper

Place a tumbler full of water on the end of a long strip of paper. Move the paper slowly and the tumbler will move with it. Jerk the paper and the tumbler will stand still.

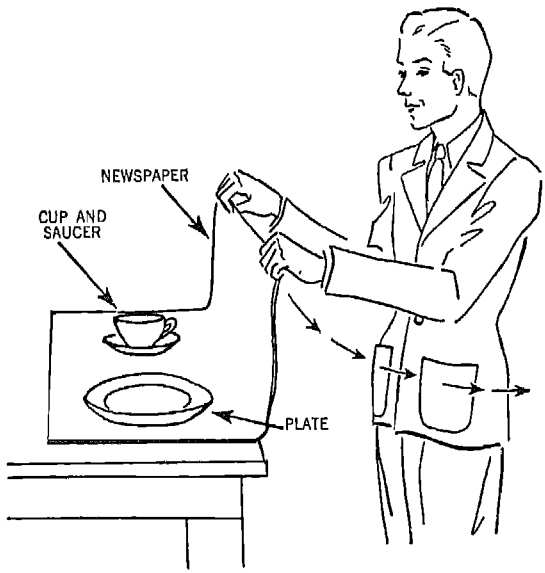


159. Rock and Cord

a. Find a piece of rock weighing about 2 lb. Tie a heavy cord around it and tie to this two lighter cords *of the same strength,* one above and the other below the rock. Tie the upper cord to a door knob or other support.

b. *Pull slowly* downward on the lower cord and the *upper* cord will break.

c. *Jerk quickly* downward on the lower cord and the *lower* cord will break.



160. Table Cloth and Dishes

For a table cloth use at least six thicknesses of newspaper, half on the table and half hanging over the side. Lay a few old dishes on the paper. Then jerk the paper horizontally with great speed, and you will find that the dishes remain on the table.

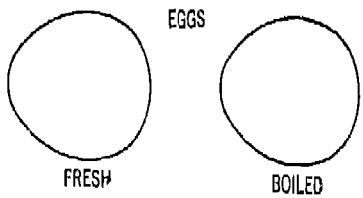
Repeat with a large table napkin instead of the newspaper.

A magician uses a *silk* table cloth for this trick because silk slides under the dishes with little friction.

161. Coins

Pile a number of similar coins (nickels) one on another.

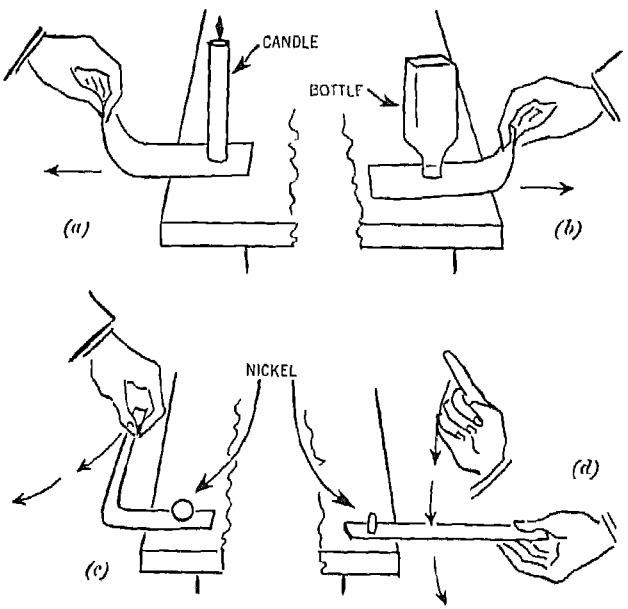
Flick a thinner coin (cent) at the bottom coin. The bottom coin will fly out and leave the remaining coins in a pile.



162. Eggs

Spin a fresh egg on its side and it will stop quickly. Spin a hard boiled egg and it will continue to turn for a much longer time.

NOTE: If the fresh egg has been in a refrigerator, let it warm to room temperature before you try this experience. The liquid inside a fresh egg is stiff when cold.



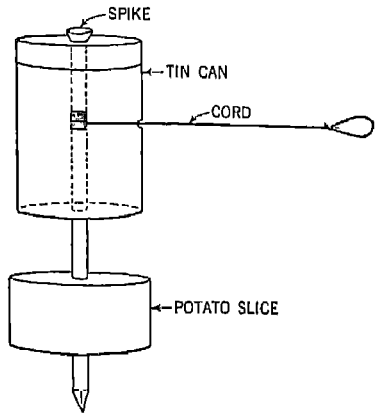
163. More Inertia Stunts

a. Stand a candle on a strip of paper, as shown. Then jerk the paper horizontally with great speed, and you will see the candle remain standing.

b. Repeat with a bottle upside down, and you will get similar results.

c. Repeat with a nickel on edge and, if you are expert, you will see the nickel remain upright.

d. Repeat with the nickel standing at right angles to the edge of the paper; hold the outer end of the paper and strike the middle very fast with a wet finger. If you are very expert, you will jerk the paper out and leave the nickel standing.



164. Tin Can Spinner

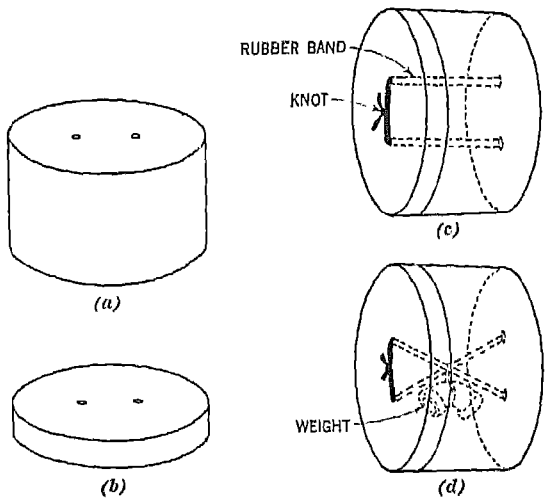
Use a long spike to punch a hole through the cover and bottom of a *small* can. Enlarge the hole so that the spike will turn easily.

Punch a hole in the side of the can and turn back the rough edges.

Cut a thick slice out of the middle of a potato. Mark a circle on it and cut the slice to the shape of a circle. Put the spike through the center of this circle.

Pass one end of a cord through the hole in the side of the can, and tie it to the spike inside. Turn the spike to wind up the cord.

Hold the can and pull the cord at the proper intervals to revolve the spike and potato first in one direction and then in the other.



165. Come Back

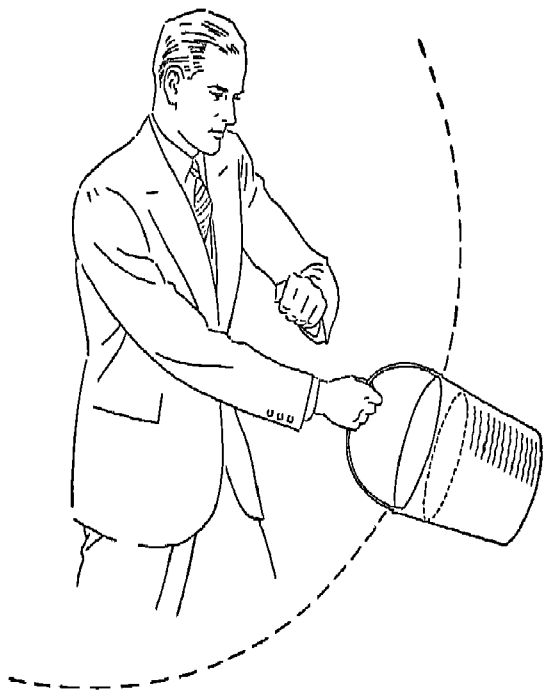
a. Find a squat one pound coffee can. Punch two nail holes in the bottom on opposite sides of the center and ¾ inches from it.

b. Punch two similar holes in the cover.

c. Find a rubber band *⅛ inch wide and 3 inches long.* Cut it at one end, pass it through the holes and tie it above the cover. *Be sure to use a rubber band of the size mentioned above.*

d. Tie a weight (a one-inch iron elbow) firmly to the middle of *both* lengths of the band.

e. Roll this can 30 feet along a *smooth* floor and it will roll back to you.

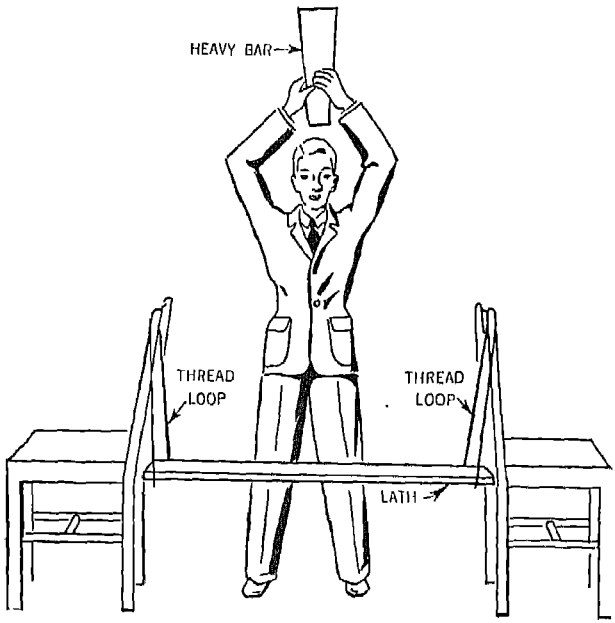


166. The Water Does Not Spill

Fill a small pail nearly full of water and practice swinging it at arms' length.

Finally swing it over your head in a complete circle without spilling a drop.

Try this also with a tumbler half full of water.

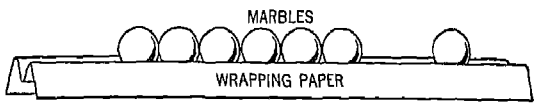


167. It Seems Impossible

Support a lath on two thread loops, as shown, and strike it hard at the middle with a heavy bar. You will break the lath without breaking either thread loop.

Take another lath and drive a tack for half its length into each end. Turn the chairs around and place a glass tumbler on each seat. Support each end of the lath with a tack resting on the edge of a tumbler. Then strike the lath hard with a heavy bar and you will break it without breaking a tumbler or a tack.

Marbles



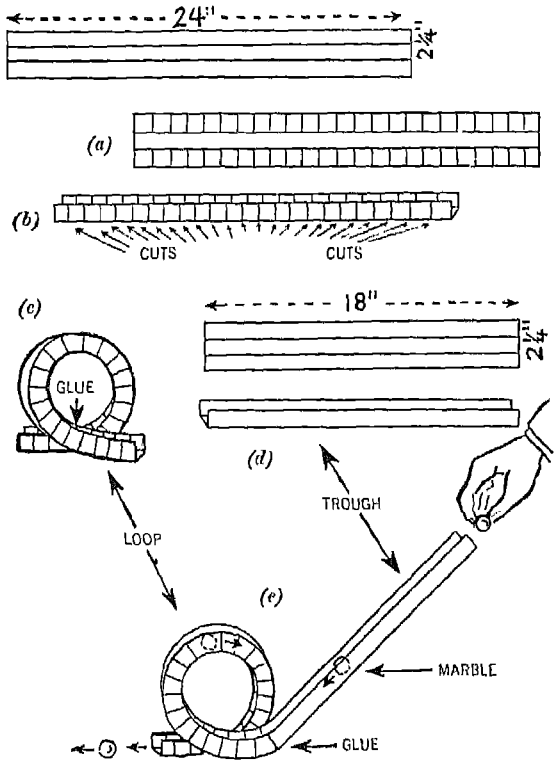
168. Marbles

Cut a strip of heavy wrapping paper 3 feet long and 3 inches wide. Fold it carefully in half lengthwise and then fold *back* each side in half.

Make this into an M shaped trough and place 8 or 10 marbles side by side and touching in the trough.

Roll one marble against the row, and the marble at the other end of the row will shoot out but the rest will remain still.

Roll two marbles against the row and the two at the other end will shoot out. Repeat with 3 and 4 marbles.



169. The Marble Loops the Loop

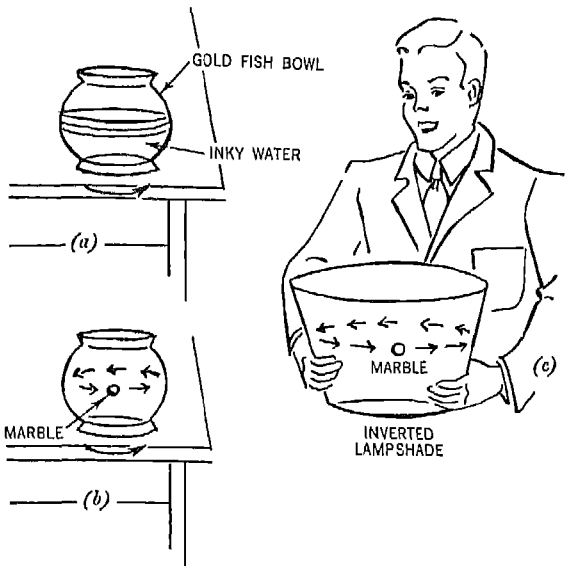
a. Find a piece of smooth heavy wrapping paper and cut a strip 24 inches long and 2¼ inches wide. With a pencil draw lines that divide the paper into three strips each ¾ inch wide. Then mark the two outer strips to form one-inch divisions.

b. Fold the outer strips up at right angles, and cut along the one-inch marks.

c. Curve the paper into a loop with the ends crossed, as shown, and glue the crossed ends side by side.

d. Cut a piece of the same wrapping paper 18 inches long and 2¼ inches wide, divide it into three strips each ¾ inch wide, and fold up the outer strips at right angles to make a trough.

e. Glue one end of the trough to one end of the loop and hold the trough and circle as shown. Now drop a marble into the upper end of the trough, and you will see it loop the loop rapidly.

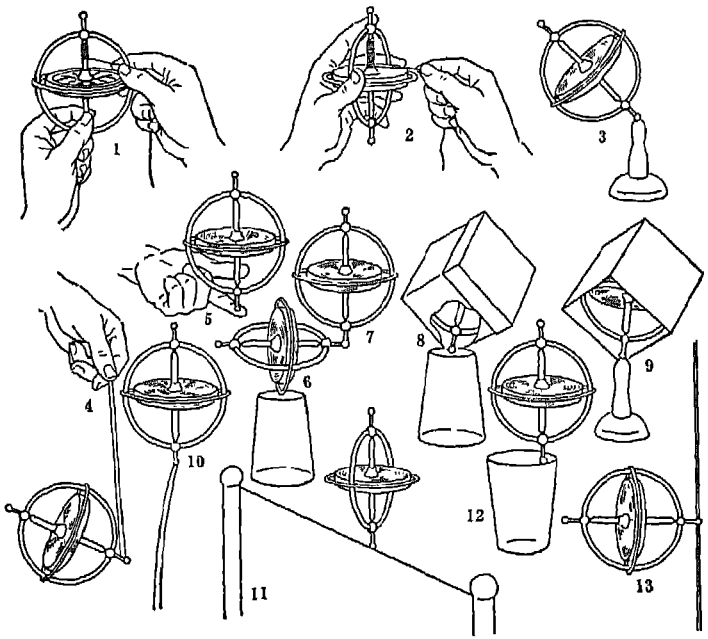


170. Centrifugal Force

a. Pour a ½-inch depth of water, colored with ink, into a spherical goldfish bowl and give the bowl a rapid circular motion sidewise. You will see the inky water rise from the bottom and form a ring on the inside at the equator of the bowl.

b. Repeat with a marble in place of the water, and you will see the marble rise from the bottom and run around inside at the equator.

c. Turn a conical lampshade upside down, throw a marble into it horizontally and quickly give the shade a circular motion sidewise. With a little practice, you will be able to keep the marble circling at the middle of the shade.



171. Gyroscope

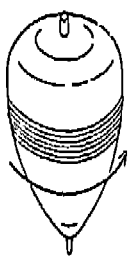
Thirteen experiences with the gyroscope are shown above.

The gyroscope appears to defy the law of gravitation.

You can see why it does as follows: spin the gyroscope as in 1 and notice the direction the wheel is revolving, then turn it upside down and notice that the wheel is revolving in the *opposite* direction.

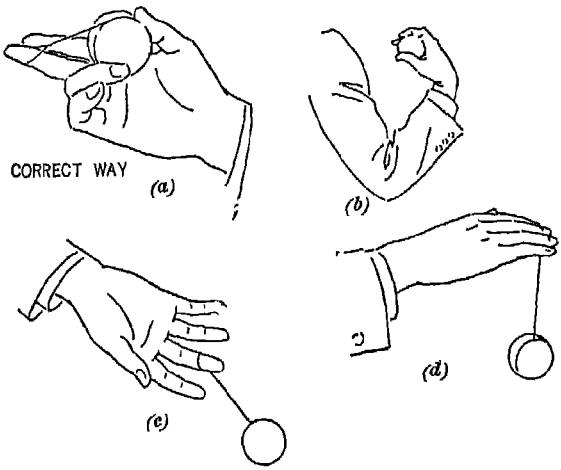
To turn the gyroscope over you must do work equal to that required to stop the wheel spinning plus the work required to spin it with equal speed in the opposite direction.

The gyroscope does not fall over until the work necessary to stop it spinning is done by friction of the air or at its bearings.



172. Top

It appears to defy the law of gravitation for the reason given in the last experience.



173. Yo-Yo

The loop projecting from the groove should be made into what is known as a slip-knot and then placed around the middle finger at the first joint.

Turn the palm of the hand upwards, as shown in *a*, not downward, and allow the top to fall over the end of the finger, as indicated in *b* and *c*.

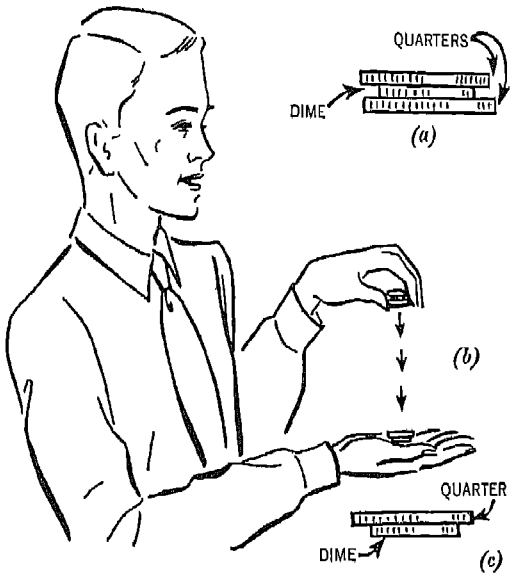
When the Yo-Yo falls within about 3″ to 6″ of the bottom, raise the hand slightly at the same time turning the palm downward to receive Yo-Yo as it approaches your hand, as indicated in *d*.

Then you will see Yo-Yo climb the string like a squirrel. The action is similar to the bouncing of a rubber ball.

If unsuccessful, rewind the string loosely in the groove of the Yo-Yo until the string has taken hold, then wind more firmly until it is all wound up.

Then repeat as before, until you have mastered the first trick of making the toy race up and down the string.

If the Yo-Yo does not come all the way back to the hand the first few times, do not grab for it, but continue the motion of raising and lowering the hand until successful in making it return by its own accord to the hand.

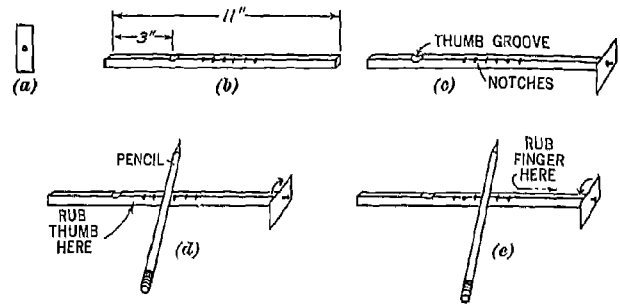


174. Surprise

a. Hold a dime between two quarters, as shown.

b. Drop the lower quarter and the dime into your hand held about ten inches below.

c. You will be surprised to find that the dropped coins nearly always turn over and that the dime is *below* the quarter.



175. Fortune Teller

a. Make a wooden propeller about 2″ × ¾″ and make a hole at its middle.

b. Make a wooden handle about 11″ × ⅜″ × ¼″. Cut a shallow thumb groove 3″ from one end and six notches ½″ apart starting 4½″ from the same end.

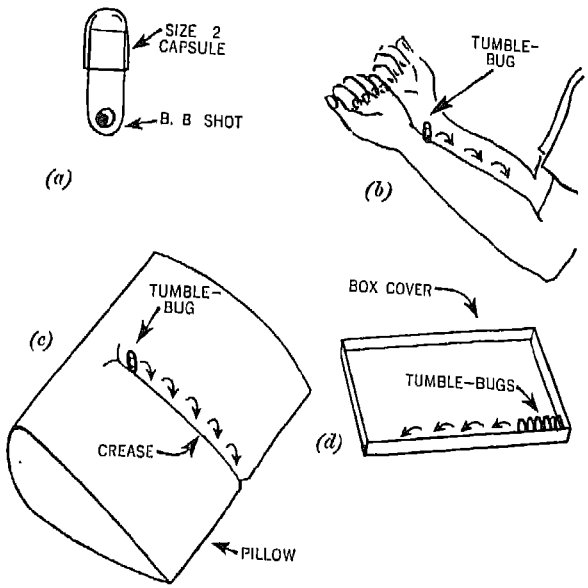
c. Nail the propeller to the other end, being sure that the hole is considerably larger in diameter than the nail.

d. Hold the stick in the left hand with the left thumb in the groove. Hold a pencil in the right hand, rub it in the notches and at the same time rub the right *thumb* hard on the *side* of the stick. The propeller will turn as shown.

e. Rub the pencil in the notches and at the same time rub the right *forefinger* hard on *top* of the stick, the propeller will revolve in the opposite direction to that in *d*.

You can pretend to answer any question in fortune telling by taking a revolution in one direction to mean "yes" and in the opposite direction, "no."

Of course, do not tell how you use your right thumb and forefinger.



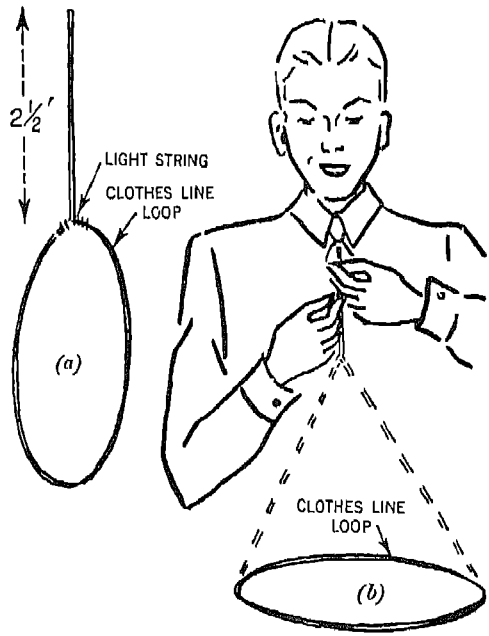
176. You Make Tumble-Bugs

a. At a drug store buy a half dozen empty medicine capsules, size No. 2, for five cents, and separate the halves with a twisting motion. Put a B.B. shot into each capsule and close them, and you will have six tumble-bugs.

b. Release one bug between your bare arms, held as shown, and you will see it tumble heels-over-head down the groove.

c. Make a sloping valley in a pillow and release a bug at the top, and you will see it go tumbling heels-over-head down the valley.

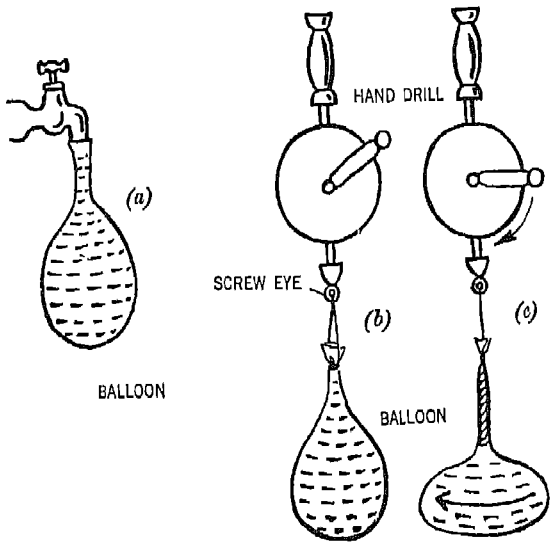
d. Stand all six bugs in one corner of an inverted box cover and tilt the cover. You will see them tumble, heels-over-head and one after the other, down the valley.



177. You Make a Lariat

a. Cut a smooth straight piece of clothes line about 7½ feet long. Keep 2½ feet for a handle and use light string to make the remaining 5 feet into a loop.

b. Twist the top of the handle to make the loop turn rapidly and you will see the loop rise and revolve in a horizontal plane.

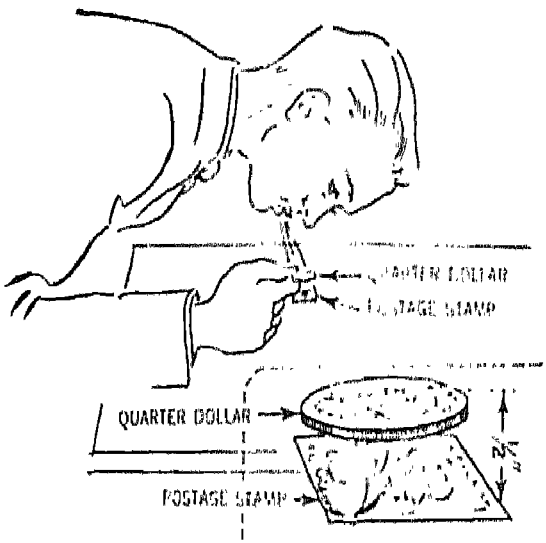


178. The Balloon Takes the Earth's Shape

a. Fill a toy balloon with water.

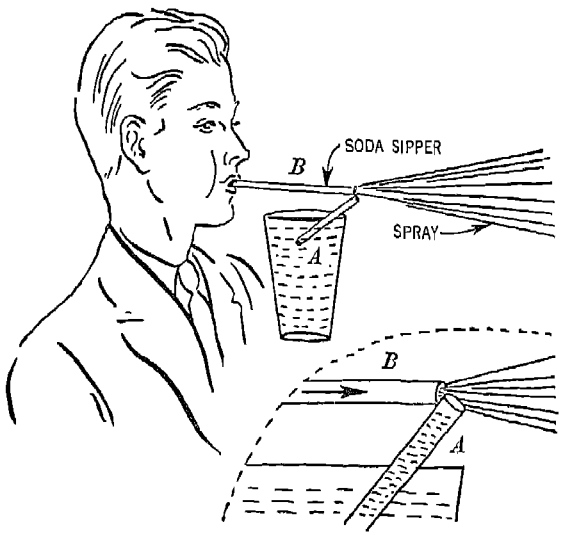
b. Tie its mouth and hang it from a screw eye in the chuck of a hand drill.

c. Revolve the balloon and you will see it take the shape of the earth—an oblate spheroid—but much exaggerated.



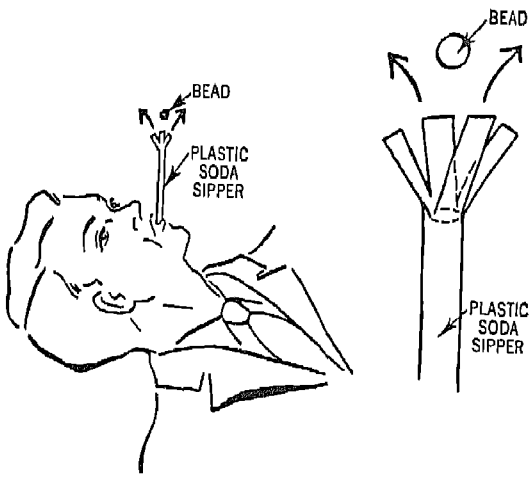
179. The Stamp Rises

Hold a quarter-dollar about ½ inch above a postage stamp. Blow down on the coin and you will see the stamp rise up to the coin.



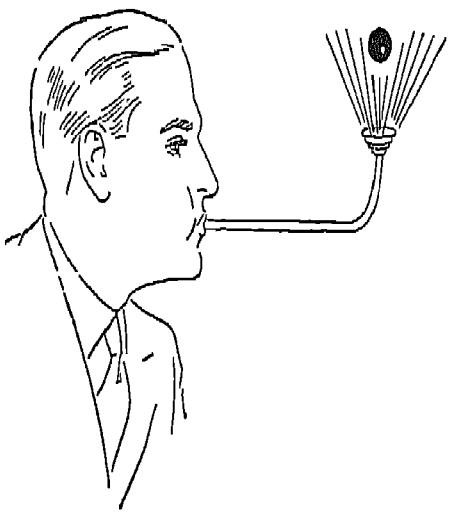
180. You Make a Spray

Cut a soda sipper into lengths of about 5 inches and 3½ inches. Hold the short length A slanting in a tumbler *full* of water. Hold the long piece B horizontal, with one end in your mouth and the *middle* of the other end at the top of A. Blow hard and you will make a fine spray.



181. The Bead Dances Up and Down

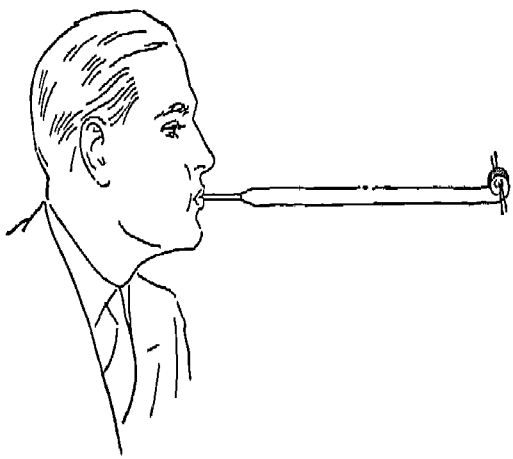
Cut one end of half of a soda sipper into four slices about 1 inch long. Bend back the slices to make a basket. Place a spherical bead or pea in the basket. Bend your head back and blow up steadily through the vertical sipper. You will see the bead or pea dance up and down in the vertical air stream as long as you keep it truly vertical.



182. Balancing Ball

Blow into the tube and the ball remains suspended in the air stream.

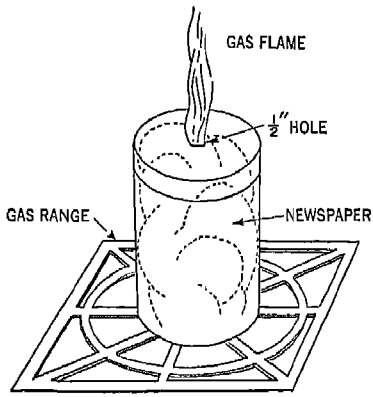
See also experiences 41 to 48.



183. Tickler

Blow into this long paper tube and the air you compress inside will uncoil it.

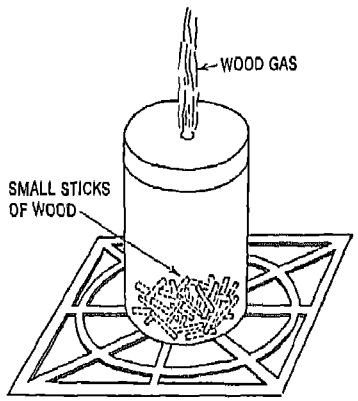
Release it, and a strip spring along one side will coil it up again.



184. A Gas Plant

Use a scissors with closed blades to punch a half inch hole at the middle of the cover of a coffee can. Crumple a page of a newspaper in the can, put on the cover and put the can *over the fire* in a range. After the water vapor has been driven off light the gas which issues from the hole. After the gas has all burned, let the can cool and examine the paper charcoal.

NOTE: The can must be in contact with the burning wood or coal or gas; or over the hot electric coils in the range.



185. To Make Wood Gas, Creosote and Charcoal

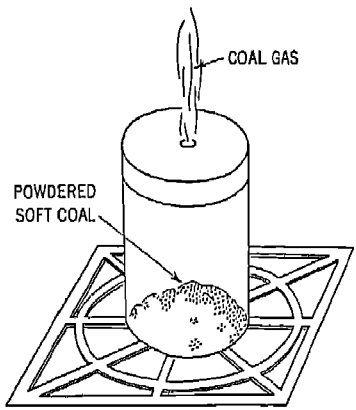
Cut wood into short narrow sticks, put a handful or two into the can and heat the can over the fire in a range.

After the water vapor has been driven off, light the wood gas which issues from the hole in the cover.

After the gas has all burned, let the can cool and examine the charcoal left in the can. This is excellent for charcoal drawings, if you used hard wood.

Smell the inside of the cover. The odor is that of creosote.

Charcoal will burn with little flame or smoke.



186. To Make Coal Gas, Coal Tar and Coke

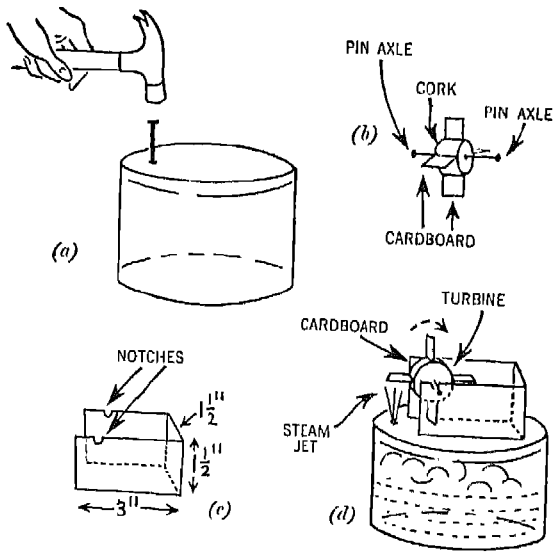
Put four heaping teaspoonfuls of broken *soft* coal into the coffee can and heat the can *over the fire* in a range.

After a time light the coal gas which issues from the hole in the cover.

After the gas has all burned, let the can cool and examine the coke left in the can.

Notice the black liquid on the inside of the cover, and smell it.

This is the coal tar from which we obtain beautiful aniline dyes.



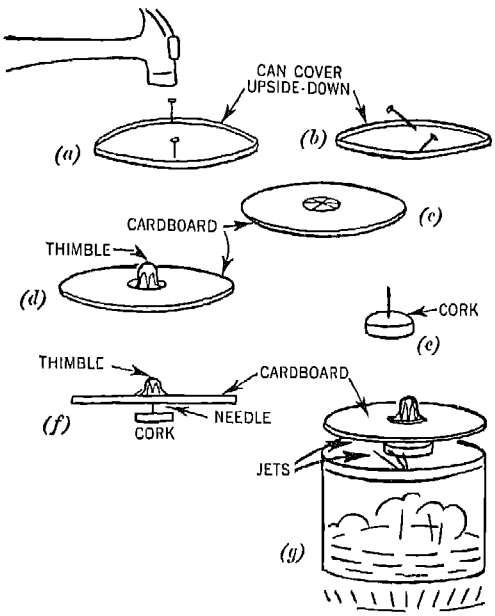
187. You Make a Steam Turbine

a. Find a can with a tight cover, and punch a *small* nail hole in the cover ½ inch from the edge.

b. To make the turbine, cut a round slice of cork about ¾ inch thick, insert four 1″ × ¾″ cardboard paddles in ¼-inch slits in the cork, and use two pins for axles.

c. To make a support for the turbine, cut a piece of cardboard 7½″ × 1½″, bend it as shown, and cut two notches to hold the pin axles.

d. Boil water in the covered can, and arrange the turbine and its support as shown. You will see the steam jet spin the turbine very rapidly.



188. You Make Another Steam Turbine

a. Find an empty broad 1-pound coffee can. Turn its cover upside down and use a *thin* nail to punch two holes, ½ inch from each edge of the same diameter.

b. Put the nail in each hole in turn and bend the holes in opposite directions.

c. On a piece of stiff cardboard draw a circle the same size as the cover of the coffee can, and using the same center draw a circle with a radius of ½ inch. Cut out the large circle and cut eight radii of the small circle.

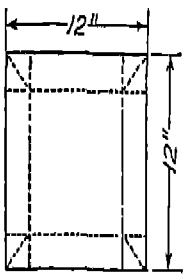
d. Shove a thimble up into the small circle.

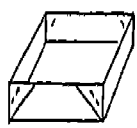
e. To make a base for the turbine, cut a slice of cork ¾ inch thick and 1½ inches in diameter or larger. Shove a needle up through the middle of the slice.

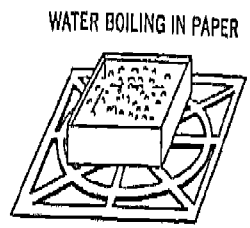
f. Place the turbine on this base with the thimble on the needle point.

g. Fill the coffee can one-third full of water, cover it, place the turbine on the cover, and boil the water.

You will see the steam jets spin the turbine rapidly.

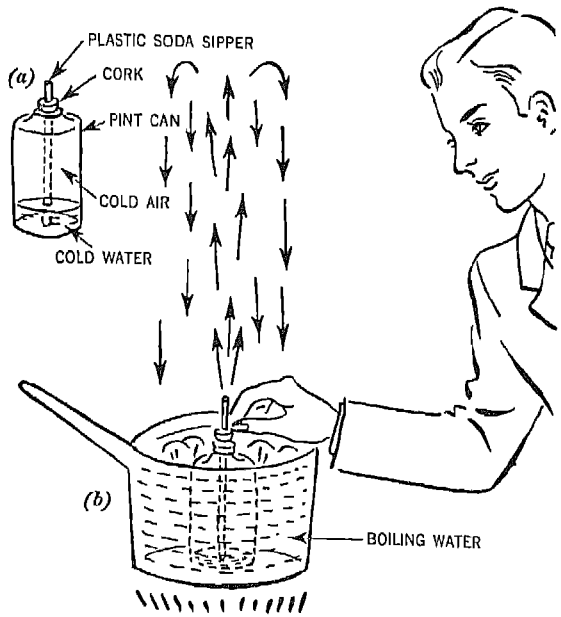






189. To Boil Water in Paper

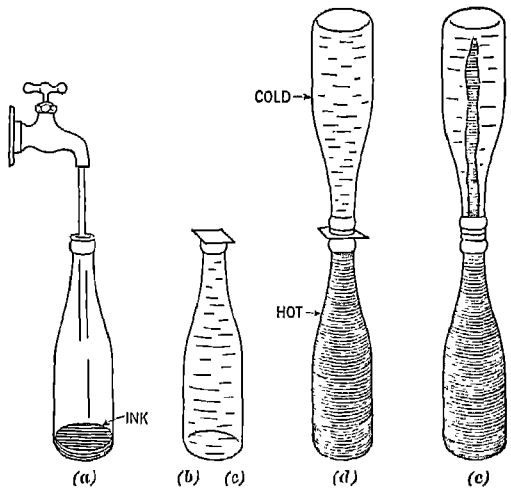
Make a paper box out of smooth *heavy* wrapping paper as above, place it over a burner, fill it half full of water and light the gas. The water simmers but the paper does not burn.



190. You Make a Cold-Water Fountain

a. Use a pint metal can similar to those used for benzine. Find a cork for it and bore a hole through the cork just large enough to hold a plastic soda sipper air-tight. Shove the plastic sipper through the cork until it is about ¼ inch above the bottom when the cork is inserted air-tight. Pour a half-cup of cold water into the can.

b. Fill a deep saucepan with water to within 1 inch of the top. Boil the water and then force the can down *to the bottom* of the pan. You will see a brief, but very vigorous, cold-water fountain.



191. The Genie

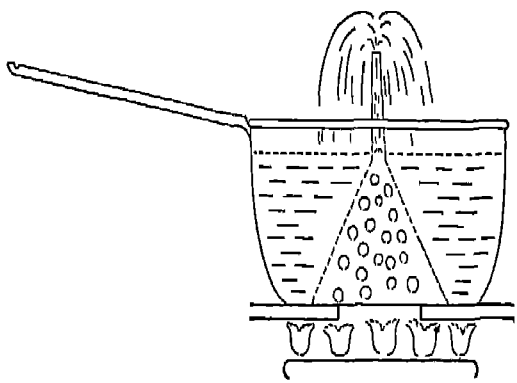
a. Pour two tablespoonfuls of ink into a soda bottle and fill the bottle with *hot* water. Wait until the air bubbles stop rising and then add more hot water.

b. Fill a similar bottle with cold water.

c. Cover the cold water bottle with $1\frac{1}{2}'' \times 1\frac{1}{2}''$ piece of wrapping paper and press the paper down hard with your thumb to squeeze out a little of the water.

d. Invert the cold water bottle and place its paper covered mouth over the mouth of the hot water bottle.

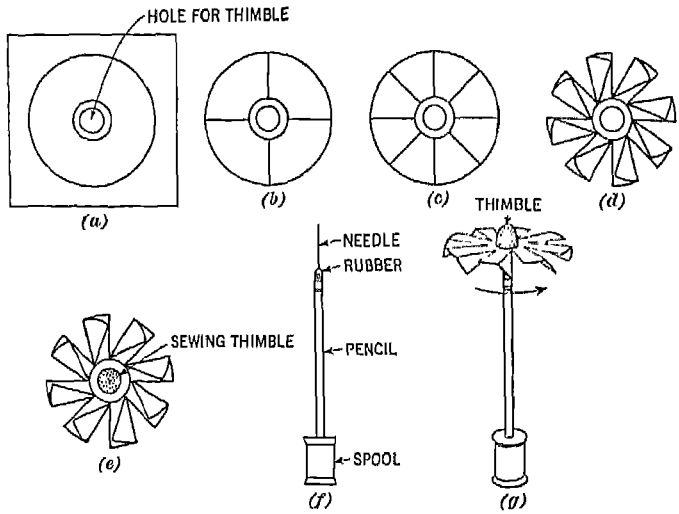
e. Slide the paper out carefully and the colored hot water will rise into the upper bottle. It will remind you of an Arabian Nights genie emerging from its bottle.



192. Percolator

Invert a large tin funnel in a saucepan and pour in water until its surface reaches part way up the stem of the funnel.

Boil the water and the funnel will "perk" enthusiastically.



193. Hot-Air Wheel

Make a hot-air wheel, as follows:

a. Draw on writing paper a circle 2½″ radius and cut it out. Draw another circle of ½″ radius. Place a sewing thimble inside the ½″ circle and draw around it. Cut out a slightly smaller circle to fit the thimble.

b. Cut from outer circle to inner circle at the quarter circle.

c. Cut from circle to circle between the above.

d. Bend half of each slice back.

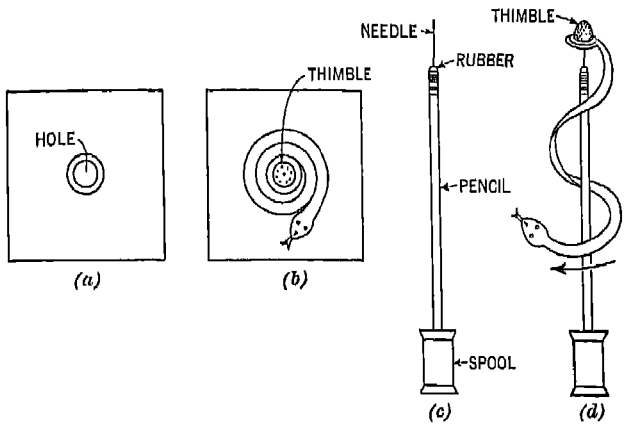
e. Insert the thimble into the center hole.

f. Tie a needle to the rubber end of a lead pencil and place the point of the pencil in a spool.

g. Bend each wing at an angle of 45° to the top. Put the end of the needle through the hole in the center and let it rest on the inside of the top of the thimble.

Place this wheel over a hot radiator and it will spin merrily.

If the radiators are not hot, hold a lighted match near the spool under the wheel and the wheel will spin merrily.



194. Hot-Air Serpent

Make a hot-air serpent as follows:

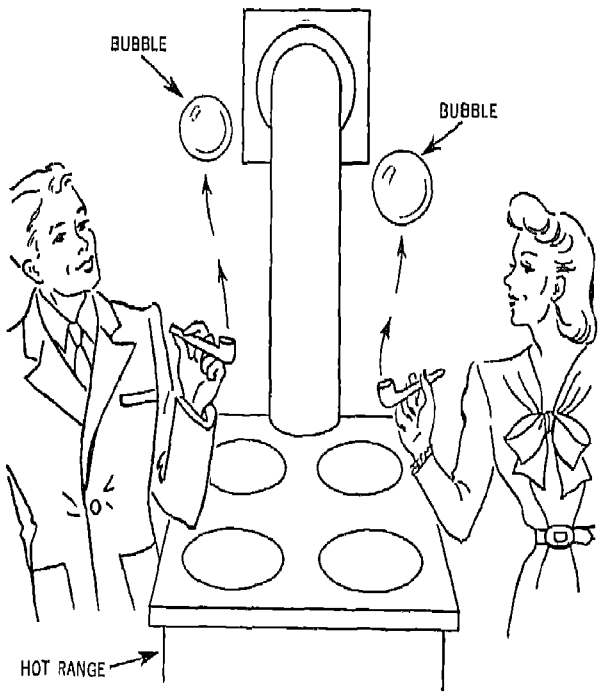
a. Place a thimble on a piece of writing paper about $6'' \times 6''$, draw a circle around it, and cut out a slightly smaller circle for the thimble.

b. Draw a spiral serpent around the thimble hole and cut out the serpent. Put in eyes and nose.

c. Make a support as in the last experience.

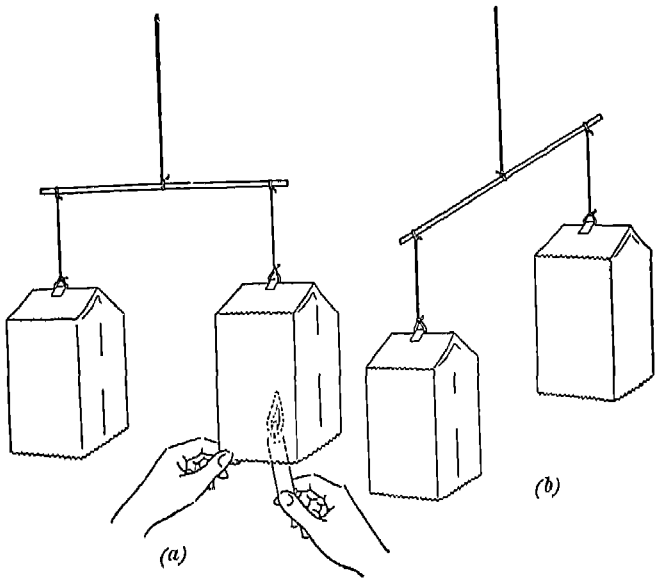
d. Insert the thimble and support the serpent.

Place this air serpent over a hot radiator and it will spin merrily, or hold a lighted match under it.



195. Bubble Balloons

Blow soap bubbles and detach them over a hot range top. The bubbles will rise as though they were balloons.

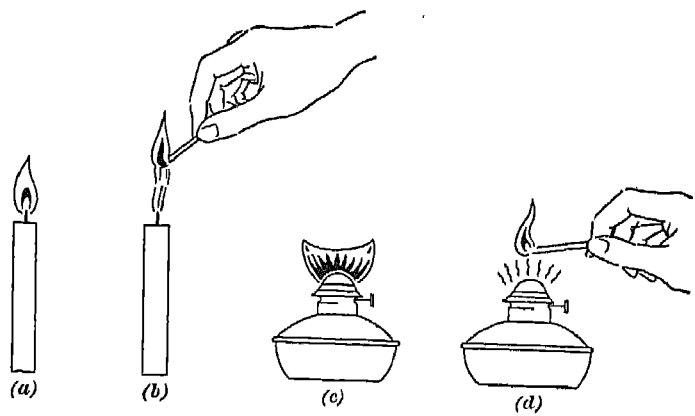


196. Hot Air Is Lighter Than Cold Air, Volume For Volume

a. Balance a stick on a cord attached to a support and balance two similar paper bags *up-side-down* near its ends.

Hold one bag and heat the air in it with a lighted candle.

b. Remove the candle and the bag will rise when it is released.



197. To Light a Candle or Lamp Without Touching the Wick

a. Light a candle and let it burn until a pool of melted candle wax forms around the wick.

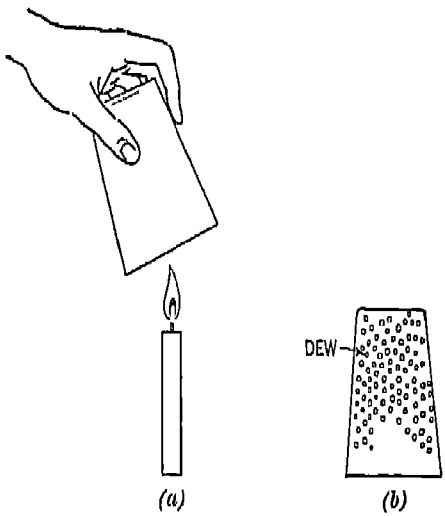
b. Blow it out and bring a lighted match down quickly into the smoke.

The wick will light before the match touches it.

c. Light a lamp and let it burn a minute or two.

d. Blow it out and bring a lighted match down quickly into the smoke.

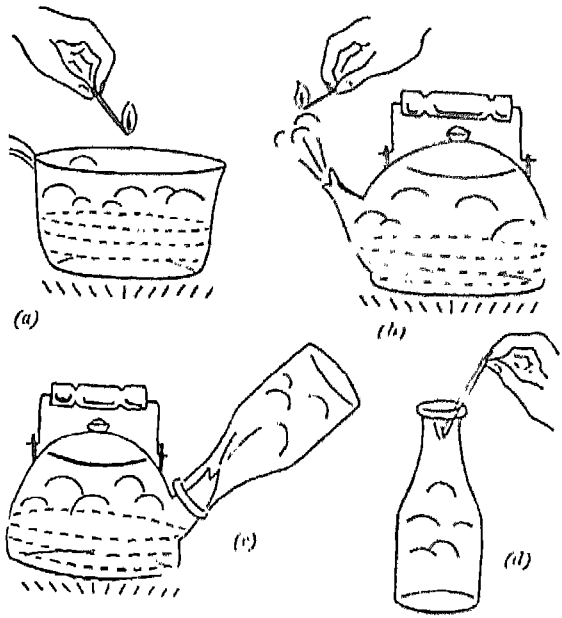
The wick will light before the match touches it.



198. To Get Water From a Flame

a. Hold a *cold* tumbler for two seconds upside down over the flame of a candle, oil lamp or gas burner.

b. Remove it and you will find water, dew, on the inside of the tumbler.



199. Steam Is a Fire Extinguisher

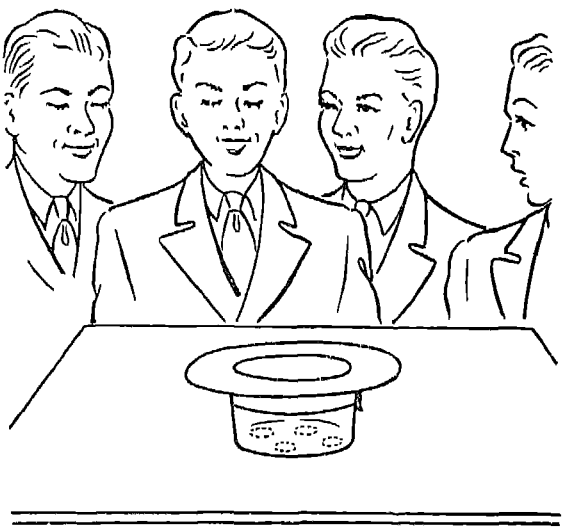
a. Boil water in a saucepan and lower a lighted match into the steam. The flame will be put out by the steam.

b. Boil water in a tea-kettle and move a lighted match through the steam. The flame will be extinguished by the steam.

c. Steam the inside of a quart milk bottle for thirty seconds or longer.

d. Move a lighted splinter down into the steam. The flame will be put out by the steam.

ADVICE: See the Note for Experience 3.



200. A Trick

Seat your friends around a table. Place a hat upside down on the table and put four quarters in the hat. Then tell your friends you can pick any quarter they lift out of the hat.

Now ask one friend to pick out a quarter, to pass it around the group so that each one can see the date on it, and then to put it back in the hat without letting you see it.

You then feel each quarter and pick out the one that is *warm*.

EXPLANATIONS

Atmospheric Pressure

The atmosphere of the earth is attracted by the earth and hence it has weight.

It exerts a pressure of 14.7 pounds (nearly 15 pounds) on each square inch of everything at the earth's surface. It exerts this pressure equally in all directions, upward, downward and sidewise, at any given place. We will call this pressure 15 pounds per square inch, for convenience.

The air in a bottle, or other vessel, open to the atmosphere, also exerts a pressure of 15 pounds per square inch.

If, however, part of the air is removed from the bottle, the air remaining has proportionally less pressure. If, for example, $\frac{1}{3}$ the air is removed, the remaining $\frac{2}{3}$ has a pressure of $\frac{2}{3} \times 15$ or 10 pounds per square inch.

If, on the other hand, the air in the bottle is increased, its pressure is increased proportionally. If, for example, $\frac{1}{3}$ more air is forced into the bottle, its pressure becomes $\frac{4}{3} \times 15$ or 20 pounds per square inch.

1—The heat of the burning paper expands the air in the bottle and thereby forces about two-thirds of it out of the bottle. This expanding air rushes out of the bottle and makes the egg dance up and down in the mouth of the bottle. When the remaining one-third cools and contracts, its pressure is only about 5 pounds per square inch. The atmosphere outside then forces the egg into the bottle against this low pressure.

Some people say that the burning paper uses up the oxygen in the bottle; this is only a small part of the cause. They are thinking of phosphorus burning in air *over water*. Phosphorus combines very vigorously with oxygen and forms a solid which rapidly dissolves in the water.

The carbon and hydrogen in the burning paper do unite with the oxygen of the air in the bottle and produce carbon dioxide gas and water vapor. They do use up the oxygen but they replace it by an equal volume of the two gases. The carbon dioxide gas remains a gas but the water vapor condenses to liquid water and thereby aids somewhat in producing the low pressure.

The chief cause of the low pressure, however, is the expansion of the air by the heat of the burning paper.

2—Air puffed into the bottle passes around the egg and increases the air pressure in the space above the egg. This increased air pressure shoves the egg out.

3—*a*. The steam drives nearly all the air out of the bottle.

d. The steam cools and condenses to water. It thereby produces almost a complete vacuum in the bottle and lowers the pressure in the bottle to nearly zero.

e. The outside atmospheric pressure of 15 pounds per square inch drives the cap into the bottle.

4—*c*. When the air in the bottle is expanded by the heat of the burning paper, it bulges the balloon rubber upward and part of the air escapes around the edges of the rubber. When the flame dies down, the air left in the bottle cools and contracts and its pressure is thereby decreased. The outside atmospheric pressure then stretches the rubber down into the bottle and breaks it with a "bang."

5—The heat of the candle flame expands the air and forces part of it out of the bottle. The flame goes out when it has used up the oxygen and the air left in the bottle then cools and contracts. This decreases the air pressure in the bottle and the atmospheric pressure on the water surface in the pan forces water up into the bottle. The candle is lighter than water, volume for volume, and is floated up by the water.

6—The heat of the burning paper forces out about two-thirds of the air in the sealer as in 1 and thereby reduces the pressure of the remaining air to about 5 pounds per square inch. The pressure of the atmosphere is 15 pounds per square inch and the difference is 10 pounds per square inch.

Since the area of the cover is about 7 square inches, you must exert a force of over $10 \times 7 = 70$ pounds to lift the cover.

7—*a*. The upward force of the atmosphere on the under side of the paper is greater than the downward force of the water on the upper side of the paper and therefore the atmosphere holds the paper on the tumbler.

b. The atmosphere presses on the thin film of water, between the rim of the tumbler and the table top, and holds the water in the inverted tumbler.

8—*d*. The steam drives nearly all the air out of the bottle.

e. The steam condenses to water and thereby produces in the bottle a vacuum of nearly zero pressure. The outside

atmospheric pressure, 15 pounds per square inch, drives air in through the sipper and blows up the balloon.

9—The atmosphere presses down on the water surface in the tumbler and stops the out flow of water as soon as the water surface reaches the mouth of the bottle.

The downward force of the air let into the bottle is less than that of the atmosphere outside. It becomes equal to the force of the atmosphere only when the water level inside the bottle is the same as that outside.

10—*a*. The steam fills the can and drives nearly all the air out of the can.

b. The steam condenses to water and leaves nearly a complete vacuum in the can which exerts practically no pressure outward. The atmosphere outside exerts a pressure inward of 15 pounds on each square inch and crushes the can.

11—The steam drives the air out of the bottle and leaves a vacuum (nearly) when it condenses.

The atmosphere presses down on the surface of the water in the pail and forces the water into the bottle.

You use *warm* water to avoid cracking the bottle.

12—*d*. The steam drives nearly all the air out of the bottle.

e. The steam condenses to water and leaves in the bottle a vacuum of nearly zero pressure. The outside atmospheric pressure, 15 pounds per square inch, then drives water up through the sipper into the bottle and produces the fountain.

13—As in 1, the pressure of the air in the bottle is reduced to about 5 pounds per square inch and this is the pressure on the part of the balloon covered by the mouth of the bottle.

The pressure of the atmosphere on the balloon outside the bottle, 15 pounds per square inch, forces part of the balloon into the bottle.

14—The pressure of the air in the bottle is reduced to about 5 pounds per square inch and this is the pressure on the part of your palm covered by the mouth of the bottle.

The pressure of the atmosphere on the remainder of your hand and body is 15 pounds per square inch and this forces your palm into the bottle.

15—*b*. The heat of the burning paper expands the air in the food jar and drives about two-thirds of it out of the jar.

c. The one-third volume of air cools and contracts when the flame is smothered and its pressure is thereby reduced to about 5 pounds per square inch. The outside atmospheric

pressure downward on the bottom of the inverted jar and upward on the under side of the plate holds them together firmly.

16—The atmosphere pressing downward through the upper hole forces the contents of the egg out through the lower hole into the low pressure space in the bottle.

17—Similar to 1.

18—When the atmospheric pressure increases, it presses down the rubber and compresses the air in the bottle. The downward movement of the center of the rubber then raises the outer end of the pointer.

When the atmospheric pressure decreases, the air in the bottle expands and raises the rubber. The upward motion of the center of the rubber then lowers the outer end of the pointer.

19—The pressure per square inch on the outer surfaces of the sink stoppers is 15 pounds. If the stoppers are 6 inches in diameter or have a 3-inch radius, the area of each is $\pi r^2 = \frac{22}{7} \times 3 \times 3 = 28+$ square inches and the force on each side is over $28 \times 15 = 420$ pounds. If there is no air between the stoppers, there is no force tending to separate them; and you must exert a force of over 420 pounds on each side to separate them.

20—Similar to 19.

21—Similar to 19.

22—Before you drive air out of the force cup, the pressure of the air in the cup is equal to that of the atmosphere, 15 pounds per square inch. If you drive out half the air, the pressure of the remaining air is 7½ pounds per square inch. If you drive out two-thirds of the air, the pressure of the remaining air is ⅓ that of the atmosphere or 5 pounds per square inch.

If the bottom of the force cup is 6 inches in diameter, the area of the bottom is 28+ square inches (see 19). The downward force of the atmosphere on the cup is 420 pounds and the upward force of the atmosphere on 28 square inches of the under side of the stool seat is 420 pounds. If two-thirds of the air is forced out of the cup, the pressure of the remaining air inside is 5 pounds per square inch, or there is a total force of $28 \times 5 = 140$ pounds upward on the under side of the cup and downward on top of the seat inside the cup. The force on each side holding the cup and stool together is $420 - 140$ or 280 pounds.

23—Similar to 22.

24—Similar to 22.

25—The can, tumbler and bottle feel heavy because you lift their weight and also the weight of water in them. The atmospheric pressure down and up balance each other.

26—When you suck air out of the bottle, you decrease the air pressure in the bottle. Then the atmospheric pressure holds the bottle and your tongue together.

27—Similar to 9.

28—*a*. The steam from the boiling water drives nearly all the air out of the can.

b. The steam condenses to water and leaves an almost complete vacuum. The outside atmospheric pressure on the water surface in the tumbler then drives the water up into the can.

29—*a*. You drive the air out of the rubber tube and funnel by filling them with water.

b. The attraction of gravity of the earth pulls down on the water in the rubber tube and funnel. It thereby decreases the upward force on the under side of the balloon produced by the atmospheric pressure on the water surface in the pail. The atmospheric pressure on the top side of the balloon then forces the balloon down into the funnel.

FLYING

30—The whirling motion of the propeller drives the air downward with a certain force and the reaction of the air lifts the propeller upward with an equal and opposite force.

31—The dart sails a long distance because its horizontal wings come continually to undisturbed air. They push this air downward and the upward reaction of the air supports the dart.

As the speed of the dart is decreased by air resistance, its wings meet less and less undisturbed air and push it downward with less and less force.

Hence the dart is supported by less and less force and glides to the ground.

32—The folded end of the paper acts as ballast to keep this end of the autogyro down.

The wings by their spinning motion come in contact with more still air than they would if they were not spinning and thereby decrease the falling speed.

Upward currents of air lift the spinning autogyro.

33—You give the cardboard energy of rotation in a horizontal plane and it continues to rotate in that plane until its energy is used up. The spinning wings are supported by the air, as in 32.

34—Similar to 30.

35—Any body set spinning in a given plane has energy of rotation in that plane and it will continue to spin *in that plane* until this energy is used up. This is the reason the boomerang does not turn over.

It spins upward at a certain angle because you start it at that angle. It spins downward at a steeper angle because the earth pulls it down.

36—The paper would fall evenly if the center of the upward air force were always opposite the center of the weight of the paper.

But when the paper glides, the center of the upward air force moves forward and tilts up the front part, mainly because the air stream moving over the top surface of the curved-up front part produces there an area of low pressure. See Experience 46, with air streams.

Folding the front edge of the paper moves the center of its weight forward and more nearly over the center of the upward air force. Therefore, the paper glides without turning over, and the upward reaction of the air supports it until it reaches the ground.

37—The contraction of the balloon rubber drives air out of the balloon in one direction with considerable force and drives the balloon in the opposite direction with equal force.

38—Any falling body must drive the air out of its way and the reaction of the air slows its fall. The cloth of the parachute, having a large area, moves a large amount of air as it falls, and the reaction of the air decreases its downward speed.

39—Similar to 30.

40—Similar to 38.

WATER STREAMS

41—*b*. Bernoulli's principle is: The pressure in a rapid stream of liquid or gas is lower than that at its sides; and the more rapid the stream, the greater the difference in pressure. The ball remains in the vertical stream because the rapid stream of water is under low pressure; and if the ball starts to fall

out of the stream, this low pressure is produced on the inner side of the ball. The greater atmospheric pressure on the outer side of the ball then pushes the ball back into the stream.

42—*b*. The rapid stream of water produces low pressure between the ping-pong ball and the inner side of the funnel. Then the atmospheric pressure upward on the under side of the ball supports the ball against the downward water pressure on its top side.

AIR STREAMS

When you produce a rapid stream of gas or liquid, you produce also low pressure in the stream. This is Bernoulli's principle.

43—The rapid air stream passing between the paper and the table produces a low pressure area between the paper and the table, and the atmosphere above the paper forces it down toward the table.

44—The rapid air stream between the card and the top of the spool produces low pressure in this space and the atmosphere above the card forces it against the top of the spool.

The harder you blow, the more rapid the stream, the less the pressure between the card and spool and the tighter the atmosphere holds the card against the spool.

45—The air stream you blow against the card is directed sidewise, upward and downward by the card and produces low pressure all around the edge of the card. The atmosphere behind the flame forces it toward this low pressure space, and blows the flame *toward* you.

46—*a*. The rapid air stream over the *curved upper surface* of the wing produces low pressure above the wing; and the atmosphere below, pressing upward on the under side, produces about two-thirds of the total lift on the wing. The under side of the wing is flat and it slants slightly upward from back to front. When the wing is in motion, the impact of the air on this under side produces about one-third the total lift on the wing.

47—The air stream divides and produces low pressure between each half-stream and the bottle. Each half-stream is held against the bottle by the atmosphere. They pass around the bottle and, uniting on the far side, blow out the flame.

48—*a*. The apple remains in the stream because the rapid stream of water produces low pressure between itself and the sides of the apple. If the apple starts to move out of the stream, this low pressure is produced between the stream and the near side of the apple. The greater atmospheric pressure on the outer side of the apple then pushes it back into the stream.

b. The rapid stream of water produces low pressure between itself and the apple. The greater atmospheric pressure then pushes them together and curves part or all of the water stream under the apple.

c. Similar to 47.

d. Similar to 45.

COMPRESSED AIR AND EXPANDED AIR

Pressure exerted on a confined gas is transmitted equally and undiminished in all directions by the gas. This is Pascal's law for gases.

49—If you blow air into the bag with a pressure of 1 pound per square inch, for example, the outward pressure on each square inch of the inside of the bag is 1 pound. If the area of one side of the bag is say 70 square inches, the total lift is 70 pounds.

50—When you blow down hard between the egg and the inside of the egg cup, you increase the pressure of the air under the egg and this increased air pressure lifts the egg over into the other cup.

51—When you blow hard at the edge of the half-dollar, you tip the half-dollar and dime and increase the air pressure under the dime. It is this increased air pressure that lifts the dime.

52—The air in the balloon expands and stretches the balloon down into the near vacuum left when the steam condenses to water. The atmosphere pressing on the outside of the balloon tends to force it into the bottle.

53—*g*. When you blow air into the bottle, you increase the air pressure in the bottle; and this increased pressure drives the water out through the long curved tube.

h. The increased air pressure drives the water out through the long tube, and part of it squirts out through the small hole into his face.

54—*b*. When you lower the carton rapidly, you compress the air in it rapidly and thereby increase its pressure rapidly. Then this increased pressure pushes the little man's tongue out.

c. When you lift the carton rapidly, you let the air in it expand rapidly. The air pressure inside thereby decreases rapidly, and the greater atmospheric pressure outside pushes the little man's tongue in again.

55—When you blow down hard, you increase the amount of air, and thereby the air pressure, between two tumblers. This increased air pressure then lifts the upper tumbler.

COMPRESSED GAS

56—The baking soda and vinegar combine and produce a large volume of carbon dioxide gas. This gas is confined in a small volume and hence exerts great force. It is this force which drives out the cork. The liquid which gushes out is white in color because it is filled with gas bubbles.

The chemical equation for the action is:

Baking soda + vinegar = sodium acetate + carbon dioxide + water

$$NaHCO_3 + CH_3COOH = CH_3COONa + CO_2 + H_2O$$

57—*a*. Similar to 56.

b. The pressure of the confined gas drives the cork and the bottle with the same force in opposite directions.

c. The materials in the baking powder combine in the hot water and produce a large volume of carbon dioxide gas. Since this is confined in a small volume, it has great force; and this force drives out the cork.

58—Similar to 56, 57.

59—The water in the sipper and bottle starts flowing downward, under the action of its weight; and its momentum, or energy of motion, keeps it flowing until the air pressure in the bottle is slightly less than that outside.

The outside air pressure then stops the flow of water downward and forces bubbles of air upward into the bottle. The momentum of the air keeps it flowing upward until the air pressure in the bottle is slightly greater than that outside.

The water starts flowing downward again, and the whole operation is repeated time after time until the bottle is empty.

You use hot water because it is much more fluid than cold water and moves through the sipper more readily.

60—*k*. Similar to 56 and 57.

WATER WHEELS AND TURBINES

61—The force of the running water turns the wheel.

62—Similar to 61.

63—*c*. The turbine revolves because the water shoots out of each corner hole in one direction with a certain force and drives that corner in the opposite direction with an equal force.

64—The water jets shoot from the hole in one direction with a certain force and drive the can in the opposite direction with an equal and opposite force.

Similarly, when you dive in one direction from the end of a boat, you spring in one direction with a certain force and drive the boat in the opposite direction with an equal and opposite force.

BUOYANCY OF LIQUIDS

65—Any body placed in a liquid is buoyed up by a force equal to the weight of liquid it displaces. This is the law of Archimedes.

a. The egg sinks to the bottom because the weight of fresh water it displaces is less than its own weight.

c. The egg floats at such depth that it displaces a weight of salt water equal to its own weight.

e. The egg floats where it displaces a weight of salt and fresh water equal to its own weight.

66—The Law of Archimedes is: The buoyant force of a liquid on a body is equal to the weight of the liquid displaced by the body.

c. The dropper *sinks* because you compress the air in it and force water in until the weight of water it displaces is *less* than its own weight.

d. The dropper *rises* because the air in it expands and drives out water until the weight of water it displaces is *greater* than its own weight.

67—*a*. Soda pop is water containing much carbon dioxide gas, CO_2, which has been dissolved in it under pressure.

b. A raisin submarine *rises* to the surface when the gas bubbles which form on it make the weight of water displaced by the raisin and gas *greater* than their combined weight.

A raisin submarine crash-dives when enough gas bubbles escape at the water surface to make the weight of water displaced by the raisin and gas *less* than their combined weight.

68—The buoyant force on the balloon in water is equal to the weight of the water displaced by the balloon.

69—*d*. After fizzing has stopped, the water still has a large volume of carbon dioxide gas dissolved in it.
e. Similar to 67 *b*.

70—When the can is empty, the buoyant force on the cardboard is equal to the weight of water that will fill the can to the water level outside the can.

71—Kerosene weighs only about eight-tenths as much as water, volume for volume. The heavier water sinks into the bottle in (*a*), into the can in (*b*), and into the lower bottle in (*c*). In each case, it lifts the lighter kerosene.

72—The buoyant force on each air bubble is equal to the weight of the water displaced by the bubble.

WATER PRESSURE AND AIR PRESSURE

73—The downward force of the air in the tumbler opposes the upward force of the water and lets the water enter only about ⅛ inch at this depth.

74—Pascal's Law is: Pressure applied to a confined liquid or gas is transmitted equally and undiminished in all directions by the liquid or gas.
d. If, here, the area of the inside of the bottle is, say, 24 square inches, and the pressure of your blow on the cork is 30 pounds per square inch, the total bursting force on the inside of the bottle is 24×30 or 720 pounds.

75—See Pascal's Law above.
c. If the area of the top of the bag is 10×7 or 70 square inches, and the water pressure at the faucet is, say, 50 pounds per square inch, the total lifting force, if you turned the water on full, would be 70×50 or 3500 pounds; and this would burst the bag.

76—*b*. When you suck air out of the can, you decrease the force of the air remaining, and the atmosphere outside drives the balloon into the can.
c. When you blow air into the can, you increase the air pressure in the can, and this drives the balloon out against the force of the atmosphere outside.

77—*b*. At the start the air pressure in the carton is the same as that outside, namely, one atmosphere. When you *raise* the carton, however, you give the air in it more room. Then

the air in the carton expands and its pressure decreases. The greater atmospheric pressure outside then *pushes air and smoke into the carton.*

c. When you *sink* the carton, you compress the air in it and thereby increase its pressure. Then this increased air pressure forces smoke and air out of the carton against the pressure of the atmosphere outside.

78—*c*. Your finger stops the inflow of air and cuts off the force of the atmosphere above the water. The upward force of the atmosphere on the water film in the hole in the cover then stops the flow of water.

79—Similar to 78.

80—*a*. When you suck air out of the rubber tube, you start the flow and both arms of the siphon are quickly filled with water. The water in each arm is supported by the atmospheric pressure on the water surface in its bottle. The water column in the long arm is, however, heavier than that in the short arm; hence, the direction of flow always is up the short arm and down the long arm.

b. Similar to *a*.

c. Similar to *a* and 41.

81—The pressure of water at any point is proportional to the depth of that point below the water surface.

82—The pressure of water is equal in all directions at a given depth.

83—*b*. When you suck out air, you decrease the pressure of the air remaining in the can, and the atmosphere outside forces the rubber into the can.

When you let air into the can, you increase the air pressure in the can, and the elasticity of the rubber moves the rubber out.

c. Similar to *b*.

84—*b*. When you shove the rubber in, you exert force on the water and produce the fountain.

85—*c*. The jets are of equal height because pressure exerted on water is transmitted equally and undiminished in all directions. This is Pascal's Law.

d. The jets are unequal because the holes are at unequal depths.

86—The contraction of the balloon rubber drives out the water.

87—*b*. The water pressure at the faucet and the contracting force of the balloon rubber exert pressure on the water, and this

pressure is transmitted by the water equally and undiminished in all directions, in accordance with Pascal's Law.

88—Explained in the text.

LIQUID SURFACES

Surface tension. The surface of any liquid acts as though it were a strong film or sheet which tends to contract to the smallest possible area. This contracting force is called the surface tension or pull of the liquid.

89—*c*, *d*. The strong surface film in each hole prevents the water from coming in or going out. The wax prevents the water from passing through the hole and from creeping along the metal because water does not wet wax.

NOTE: The water surface is only strong enough to prevent water from entering or leaving very shallow vessels.

90—The strong surface film of water is bent downward by the steel razor blade, but it is strong enough to support the blade.

91—*b*. The atmospheric pressure upward on the water film in the hole supports the water in the bottle because, after the cork is put in, a few drops of water run out through the hole and create under the cork a partial vacuum which exerts very little pressure downward on the water surface.

c. The atmospheric pressure upward on the water film in the hole is now balanced by the atmospheric pressure downward on the water surface, and the water runs out by gravity because the water film is too weak to hold it in.

92—Similar to 90.

93—The strong surface film on both surfaces holds the water in the form of sheets.

94—*c*. The water surface is bent down by each wax-covered foot, but it is strong enough to support a light beetle. Water does not wet wax.

95—The strong surface film of the water holds the heaped up water in the tumbler.

96—*d*. The surface is strong.

f. Since the 4"×2" part is wet, it has a surface film of water on both sides.

The surface film of the water in the pail unites instantly with that on the 4″×2″ part. They contract to the smallest possible area, and in doing so *jerk* the 4″×2″ part down.

The surface films, on the water in the pail and on the 4″×2″ part, resist being stretched, and in doing so stretch the zigzag part.

97—Similar to 96.

98—*d*. The strips are separate because there is no surface film under water to hold them together.

e. The strong surface film of water holds the strips together.

99—*d*. The water enters the cells of the cellulose in the paper and *swells* them.

e. This swelling of the cells at the crease separates the jaws *against* gravity and *against* the pull of the surface film of water which is trying to hold them shut.

100—*b*. The strong surface film of the water holds the jets together.

101—The strong surface film of the water holds the water in contact with the pencil or string.

102—*c*. When the hole is open, the water runs out by gravity, because the upward pressure of the atmosphere on the water in the cloth is balanced by the equal downward pressure of the atmosphere on the water in the can.

When the hole is closed, the air in the can expands as the water continues to flow out, and its pressure decreases slowly. The water outflow stops slowly when this decreased air pressure plus the downward pressure of the water is balanced by the upward pressure of the atmosphere on the water films in the cloth meshes.

d. The water runs out of the hole by gravity as long as there is any water above the cloth, because the atmospheric pressure downward on the water above the cloth balances the atmospheric pressure upward on the water in the hole.

As soon as all the water is below the cloth, however, the strong water films in the cloth meshes cut off the downward atmospheric pressure promptly, and the upward atmospheric pressure on the water film in the hole stops the flow promptly.

103—*b*. The atmospheric pressure upward on the water films in the cloth meshes supports the water.

104—Similar to 103.

105—Similar to 103.

106—Soap added to water decreases the surface tension or pull of the water to less than one-half its usual strength. The pure water surface, not touched by the soap, is over twice as strong as the soapy water surface; it contracts to the smallest possible area, and in doing so pulls the talcum powder with it and stretches the soapy water surface.

107—The surface tension or pull of gasoline is only about one-third that of water. The pure water surface, being three times as strong as the gasoline surface, contracts to its smallest possible area and pulls the talcum powder with it to the side of the plate against the pull of the gasoline surface.

As the gasoline evaporates, it leaves the water; and the water surface formerly covered by the gasoline comes into play. It contracts and pulls the talcum powder away from the side of the plate.

108—The strong pure water surface outside the loop pulls the loop out in all directions and stretches the weaker soapy water surface inside the loop.

The fact that the loop becomes a perfect circle proves that the pull of the pure water surface outside the loop is equal in all directions, and also that the pull of the weaker soapy water surface inside the loop is equal in all directions.

109—The first drop of kerosene weakens the water surface and this permits the surface tension of the kerosene to draw the later drops of kerosene into a large round disk-like drop in the water at the center of the plate.

Soap touched to the surface above the kerosene weakens the surface at this point still further and permits the now stronger water surface around it to pull the kerosene and talcum powder to the edge of the plate instantly.

The whole water surface is now soapy and weak, and the surface tension of the kerosene, being stronger, pulls the kerosene into spherical drops.

Remember that any liquid surface contracts to the smallest possible area, and the sphere is the shape which has the smallest possible area for a given volume. Hence, the kerosene is drawn into spheres by its surface tension.

Similarly, rain drops are spheres because the surface tension of water draws the falling water into this shape.

110—*a.* Camphor dissolves in water irregularly; and where it dissolves most, it weakens the surface most. The stronger

water surface on the opposite side then draws the camphor to that side.

Next instant the camphor is dissolving more rapidly at another point, and the camphor is pulled in the direction opposite this point.

Hence, each camphor particle moves about in a very irregular manner.

b. The soap weakens the water surface much more than does the camphor, and the stronger water surface around the edge pulls the camphor particles to the edge of the plate.

The camphor particles stop moving because the whole surface is now soapy and so weak that the camphor particles have no further weakening effect.

111—The camphor at the stern weakens the water surface at the stern, and the stronger water surface at the bow pulls the boat forward.

112—The soap speck dissolves irregularly in water and the results are similar to 110*a*. The soap weakens the water surface so much more rapidly than does the camphor that its irregular motions stop sooner than do those of camphor.

113—The soap or camphor weakens the surface tension of the water surface in the spiral and at its outlet. The stronger water surface on the far side of the spiral opposite the outlet pulls the spiral around.

114—*b*. The thick coating of soot on the paper prevents the water from touching the paper; hence, the surface tension of the water can draw it into drops.

The attraction between water and paper is stronger than the attraction between water and water. Hence, water which touches the paper is drawn down into the paper and the drop is destroyed.

115—*b*. Similar to 114 *b*.

116—*a*. A cushion of steam is formed under the water the instant the water strikes the red hot tin. This cushion keeps the water above the metal, and the surface tension of the water draws it into spheres. The water changes into steam continuously and in time disappears.

b. The surface tension draws the water into spherical drops.

117—Woolen cloth can be used to handle soap bubbles because wool does not absorb water readily.

118—Similar to 117

119—Any liquid surface tends to contract to the smallest possible area.

120—This shows that a liquid surface contracts to the smallest possible area.

121—This shows that the tension or pull of the soap film is equal in all directions.

OTHER PROPERTIES OF WATER

122—Water passes through the skin of the peas or beans and swells them with such great force that it bursts the bottle. This force is called Osmotic Pressure.

Water swells seeds planted in moist ground with this same great force.

123—Similar to 122.

124—In osmosis the liquid always moves toward the stronger solution, or the solution where the liquid is least concentrated. In this case the water moves from the tumbler through the membrane of the egg into the stronger solution in the egg. It moves with sufficient osmotic pressure to drive the contents of the egg up through the straw.

125—The skin of fruits, seeds and vegetables is a membrane permeable to water but not to the substances in solution in the juices of the fruits, seeds and vegetables.

Water moves through the skin by osmosis and swells the fruits, seeds and vegetables by osmotic pressure.

126—Heat is required to turn water into water vapor. Part of this heat comes from the air and part of it from the water on the cloth. The loss of this latter heat cools the cloth.

127—If you wish to boil water on the stove, you must supply heat to warm the water and to turn the water into steam.

When you blow on your hand, you change perspiration (water) into water vapor (steam). The heat to do this comes partly from your hand, and your hand feels cool.

128—The ice cools the warm moist air, and the water molecules in the air come together as small water drops. Millions of small water drops make a fog or cloud.

When these small drops come together as larger drops, they become rain.

129—*d*. When you puff into the bottle, you heat the air in it, partly by the heat of your breath and partly by compressing the air. This heat evaporates the visible fog of water drops into invisible vapor.

c. The compressed air in the bottle expands, and thereby cools, when you lift your mouth. This cooling condenses invisible water vapor into small visible water drops and you see fog.

130—The ice and salt produce a temperature below freezing, that is, below 32° F.

They cool the air which comes into contact with the can and cause the water molecules from the air to collect on the can as *dew* drops; then they freeze these drops to ice and produce *frost*.

They freeze the water beneath the can to ice which cements the paper to the can.

131—Water in nature has air dissolved in it, and fish in water live by absorbing this air through their gills.

Water delivered to you through pipes has been in contact with air under high pressure and it has dissolved more air than water in brooks.

It is this excess air which appears at the top of the bottles.

132—One substance dissolved in water is driven out by another substance which dissolves more readily in water.

Air is driven out of water by salt which dissolves in water more readily than does air.

133—Carbon dioxide gas is driven out of water by sugar, which dissolves in water more readily than does the gas.

134—The molecules of sugar dissolved in water are in constant and rapid motion just as the molecules of water are.

The molecules of sugar gradually move upward against the force of gravity and in time distribute themselves uniformly through the water. This process is called diffusion. It occurs in every solution in nature. The soap acts in a similar manner.

135—When alum separates as a solid from a concentrated solution, it forms in regular geometrical forms called *crystals*.

Many substances do this, for example, salt, sugar, and ice.

136—Tiny crystals of salt form where the pen has left a trace. They scrape more lead from the pencil than does the surrounding paper, and the writing is thereby made visible.

137—When water turns to a solid, it produces at first long thin crystals of ice. You may have seen these on the edge of a brook or pond or as shell ice on water puddles.

A pound of ice occupies more space than a pound of water because there are open spaces between the crystals.

Similarly a pound of iron nails occupies more space than a pound of iron because no matter how closely you pack the nails there are open spaces between them.

All ice crystals tend to form as pure water solidified and to exclude all substances dissolved in the water. Hence, the first ice crystals formed exclude the air dissolved in the water. The later ice crystals have air mixed with them, not as invisible dissolved air but as excluded visible air bubbles.

138—Water in forming ice crystals expands with enormous force and bursts the bottle.

Similarly, ice forming in iron water pipes may burst the pipes.

139—Ice at the freezing temperature of water, 32° F., evaporates almost as readily as water at the same temperature. The ice turns to water vapor without going through the liquid stage. Hence, the towel dries although the water on it is in the form of ice.

BALANCE

140—Any body is balanced when the imaginary straight line from its center of gravity to the center of the earth passes inside its base.

The center of gravity of any body is the center of its weight.

When you bend over to pick up the handkerchief you begin to fall, because the vertical line from your center of gravity passes outside your base, your feet.

141—Your base at first is the space covered by your feet and the space between two lines running from the outside of your feet to some point beyond the wall.

The instant you remove your head from the wall, however, your base is only the space covered by your feet.

The vertical line from the center of the combined weight of your body and the chair passes very far outside this base and you are too much out of balance to straighten up.

142—You tip over unless you keep your center of gravity over your base—the space between the lower legs of the chair.

143—It is balanced when the vertical line through the center of gravity of the whole device passes through the point of support—the base.

144—Similar to 143.

145—Similar to 143.

146—Similar to 143.

147—*d*. The center of gravity of the combined weight of the half-potato, the man and the sipper is a little to the right of the point of support on the rim of the potato.

c. The attraction of the earth pulls the center of gravity down and thereby pulls the little man upright.

148—*c*. The figure balances when the center of gravity of the combined weight of the man, horse, wire and spool is vertically below the point of support, namely, the bottom of the cork.

149—*b*. Similar to 148 *c*.

150—The pennies inserted near the tips of the wings move the center of the weight of the butterfly and pennies up to the head of the butterfly. They also bend the wings down slightly and bring the center of weight slightly below the head. The butterfly will balance if the pencil head is in the vertical line through the center of weight.

EXPERIENCES WITH YOUR BODY

151—Your friend's outstretched arms make a long lever which you can turn up or down by exerting force at the end of the lever and at right angles to it.

152—Similar to 151.

153—Your hand trembles slightly no matter how steady you try to hold it and these small movements move the hair pin.

154—*a*. Your pulse tips the thumb tack and the thumb tack moves the match.

b. Your pulse moves the mirror and the mirror moves the reflected light.

155—This takes a little practice.

INERTIA

Inertia is defined as the tendency of a body at rest to remain at rest and the tendency of a body in motion to continue in motion in the same straight line.

156—The inertia of the egg keeps it at rest while you jerk the cardboard and match box sidewise. It is then pulled down into the egg cup by gravity, the attraction of the earth.

157—The inertia of the coin keeps it at rest while the card slides out from under it.

The coin then falls into the bottle because it is pulled downward by the attraction of the earth.

158—The inertia of the tumbler and water is overcome when you move the paper slowly but not when you move the paper rapidly.

159—When you pull down slowly, the force on the lower cord is your pull, while the force on the upper cord is your pull plus the weight of the rock. The upper cord breaks.

When you pull down quickly, the force on the lower cord is your pull plus the inertia, or resistance to motion, of the rock, while the force on the upper cord is only the weight of the rock. The lower cord breaks.

160—The inertia of the dishes keeps them at rest when you jerk the table cloth quickly from under them.

161—The inertia of the upper coins is not overcome when the bottom coin shoots out, and the pile remains upright but shorter by one coin.

162—A fresh egg at room temperature is fluid inside, and when you spin it you spin the shell but not its contents. The inertia of the contents stops the shell quickly.

A hard-boiled egg is solid inside, and when you spin it you spin the shell and its contents; and the inertia of motion of the contents keeps the egg spinning.

163—Similar to 158.

164—The inertia of motion of the potato keeps it moving after you have stopped pulling on the cord, and it winds up the cord in the reverse direction.

165—The weight keeps the center of the bands from turning, and the inertia of motion of the can twists up the bands on both sides of the weight. The resistance to twisting in time stops the motion of the can, and the energy of twisting stored up in the bands rolls the can back.

166—The inertia of motion of each particle of water tends to make it move at each instant along the straight line in which it is then moving—a tangent to the circle. This tendency keeps the water in the pail. It is overcome by the pull of your arm toward the center of the circle.

167—*a*. The *inertia* of the ends of the lath, that is, "their tendency to remain at rest," prevents them from breaking the threads, tumblers or tacks.

MARBLES

168—The energy of motion of each rolling marble is transmitted from one marble to the next by the compression and expansion of each marble in turn, and this energy is finally given to the end marble.

169—The inertia of motion of the marble keeps it moving and also pressing outward on the inside of the circle. As a result the marble loops the loop inside the circle.

170—*a*. The energy of the circular motion you give to the water keeps it moving and makes it press outward against the inside of the bowl until it leaves the bottom and reaches the widest part of the bowl at the equator.

b. Similar to *a*.

c. You give it just enough energy of circular motion to keep it moving around the middle of the lamp shade.

SCIENCE TOYS

171—Explained in the text.

172—The inertia of motion of the spinning top tends to keep it spinning *in the same plane* for the reason given in 171. Hence, the top does not fall over until its energy of motion is overcome by the friction of the air around it and by the friction between its point and the floor.

173—The inertia of motion of the Yo-Yo tends to keep it moving and winds it up hill on the cord.

174—*c*. It is nearly impossible to release both sides of the quarter at the same instant, and the side first released starts at once to turn about the opposite side. This turning motion continues as the coins fall, and the dime lands *below* the quarter.

175—The end of the stick is given a jolt each time the pencil drops into a notch, and the pressure of the thumb on the side of the stick makes these jolts follow one another in a circular path in one direction. This motion of the end of the stick sets the propeller revolving in the same direction.

The pressure of the finger on the top side of the stick makes the jolts follow one another in a circular path in the opposite direction, and this motion of the end of the stick sets the propeller revolving in the opposite direction.

176—The weight of the B.B. shot is greater than that of the capsule. When the tumble-bug is placed on an incline, the heavy B.B. shot first tips the capsule down the incline; then it rolls from

rear to front and its energy of motion tips the capsule down the incline again; and so on, time after time. Hence, the tumble-bug goes heels-over-head down the incline.

177—Any rapidly revolving body which has its point of support *above* its center of gravity always revolves about its *shortest* axis.

178—The centrifugal force of the revolving drops of water causes the balloon to bulge sidewise.

179—Similar to 45 and 48*d*.

180—By Bernoulli's Principle (see 43), the rapid stream of air from B produces low pressure at the top of A. Then the atmospheric pressure on the water surface in the tumbler lifts water to the top of tube A, where the air stream from B breaks it up into very small drops.

181—The bead or pea remains in the vertical air stream because, when it starts to fall out, low pressure is produced between the air stream and the side of the bead or pea nearest the air stream (Bernoulli's Principle); and the greater atmospheric pressure on the opposite side pushes it back in again.

182—The air streams on all sides of the ball produce an area of low pressure between the ball and the streams. If then the ball starts to fall out of the stream, the greater atmospheric pressure on the side away from the stream forces the ball back into the air stream.

183—A curled spring along one side of the tube keeps the tube curled up. When you blow air into the tube with a given pressure, the air transmits this pressure equally and undiminished to every part of the inside of the tube, and the total force outward is great. This force straightens the tube.

HEAT

Manufactured gas is made by the destructive distillation of organic matter, for example, hay, straw, wood, coal and oil.

Destructive distillation is the breaking up of organic matter by means of heat.

184—Paper is made from wood, and the heat breaks it up into water vapor, gas, creosote, and charcoal.

185—Similar to 184.

186—The heat of the burner breaks up the coal into coal gas, coal tar and coke.

187—The steam jet strikes the blades and revolves the turbine very rapidly.

188—The slanting steam jets strike the under side of the cardboard, the turbine, in opposite directions and revolve it very rapidly.

189—The boiling temperature of water is 212° F., and the temperature at which paper takes fire is much above 212° F. The paper conducts heat so rapidly from the flame to the water that its temperature does not rise much above 212° F.; and since this temperature is below its kindling temperature, the paper does not take fire.

190—The heat of the boiling water expands the air in the can rapidly, and the pressure of this expanding air drives the cold water up the soda sipper as a brief but vigorous fountain.

191—The cold water is heavier than hot water, volume for volume. Cold water from the upper bottle sinks to the bottom of the lower bottle and forces the hot colored water upward. The ink drives air out of the hot water. See 132 and 133.

192—The steam forming in the funnel can force its way out either through the stem of the funnel or down under the inverted top of the funnel. It forces its way out of the stem and carries water with it in "perks" because the mixture of water and steam in the funnel and funnel stem is lighter volume for volume than the water outside the funnel. A coffee percolator "perks" for the same reason.

193—Cold air is heavier volume for volume than hot air. The cold air around the source of heat sinks down and lifts the hot air above the source of heat and thereby produces an upward current of hot air which turns the hot-air wheel.

194—Similar to 193.

195—Similar to 193.

196—Cold air is above, below and on all sides of the hot air in the bag. It is heavier volume for volume than the hot air, and it lifts the hot air up just as water lifts up a piece of wood shoved down into it.

197—*b*. The hot candle wax turns to oil, the oil turns to gas, and it is the gas which burns. The smoke is mostly gas and it lights readily.

d. The oil on the wick turns to gas, and it is the gas which burns. The smoke is mostly gas and it lights readily.

198—The candle, oil and gas in burning produce chiefly carbon dioxide gas and water vapor. You detect the water vapor.

199—Steam is water in the form of gas. It neither burns nor supports combustion and it smothers the fire by excluding air.

200—Each person who handles the quarter to read the date warms it, and you pick out this warm quarter.

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